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SCIENCE 7

Module 3 Heat and Temperature

Learning Technologies Branch

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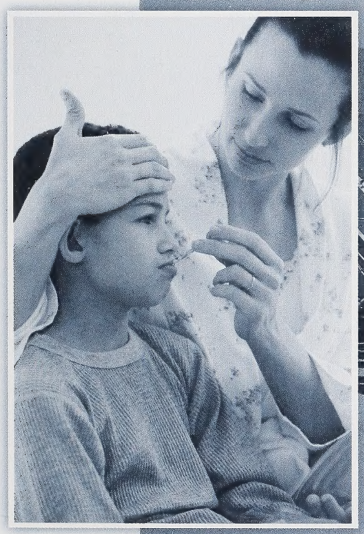
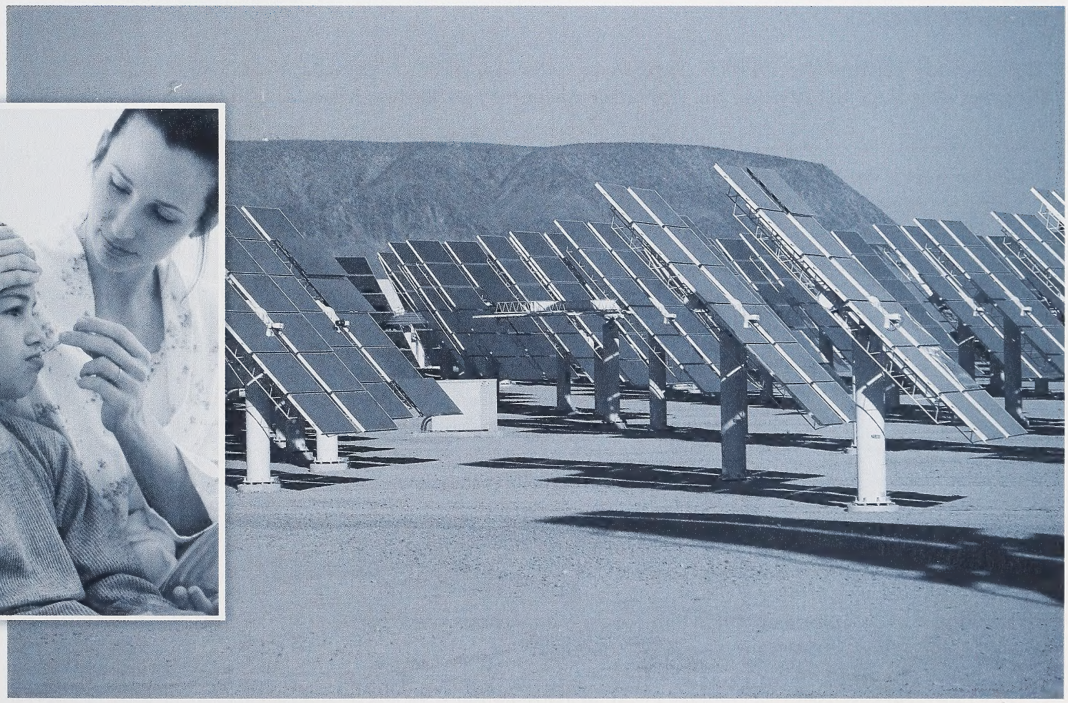
SCIENCE 7

Module 3

Heat and Temperature





Learning Technologies Branch

Alberta LEARNING

Science 7
Module 3: Heat and Temperature
Student Module Booklet
Learning Technologies Branch
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The Learning Technologies Branch acknowledges with appreciation the Alberta Distance Learning Centre and Pembina Hills Regional Division No. 7 for their review of this Student Module Booklet.

This document is intended for	
Students	✓
Teachers	✓
Administrators	
Home Instructors	
General Public	
Other	

You may find the following Internet sites useful:

- Alberta Learning, **http://www.learning.gov.ab.ca**
- Learning Technologies Branch, **http://www.learning.gov.ab.ca/ltb**
- Learning Resources Centre, **http://www.lrc.learning.gov.ab.ca**

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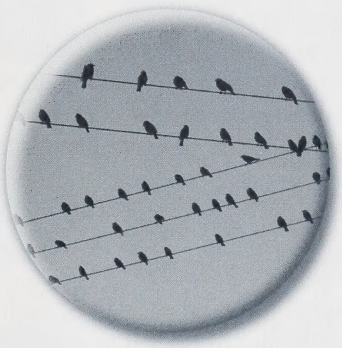

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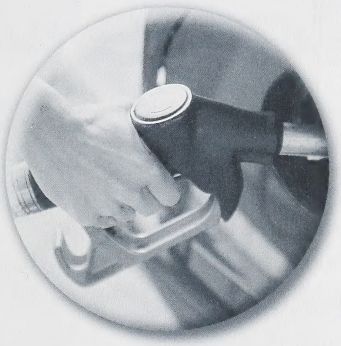

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Resources

Textbook

To complete the course, you need the textbook *ScienceFocus 7*.

Multimedia

Attached to Module 1 of this course is a CD titled *Science 7 Multimedia*. This CD contains multimedia segments designed to help you better understand particular concepts presented in this course. Ask your teacher or home instructor if you need help using this CD.

Materials and Apparatus

A list of materials and apparatus is given on page 10 of each Student Module Booklet. These items are needed to complete the module. Some of the materials and apparatus may be provided at your local school lab. If you don't have access to a school lab, you will need to get the loan kit. Talk to your teacher for more information.

Before You Begin

Organize your materials and work area before you begin: Student Module Booklet, textbook, notebook, pens, pencils, and so on. Make sure you have a quiet area in which to work, away from distractions.

Because response lines are not provided in the Student Module Booklet, you'll need a looseleaf binder or notebook to respond to questions and complete charts. It's important to keep your lined paper handy as you work through the material and to keep your responses together in a notebook or binder for review purposes later.

Refer to the Planning Ahead page for directions on what you need to do before you start this module.

Icons

This is one of five Student Module Booklets for Science 7. As you progress through this module, you will meet several icons.

Do Ahead

Some preparation must be started well ahead of the activity or investigation. For example, start the seedlings for the investigation in Lesson 3.

Teacher or Home Instructor

The teacher or home instructor should be contacted for help, approval of some procedure, or checking answers.

Assignment Booklet

Work needs to be done in one of the Assignment Booklets.

Safety

You must be very careful when you see this symbol.

Textbook

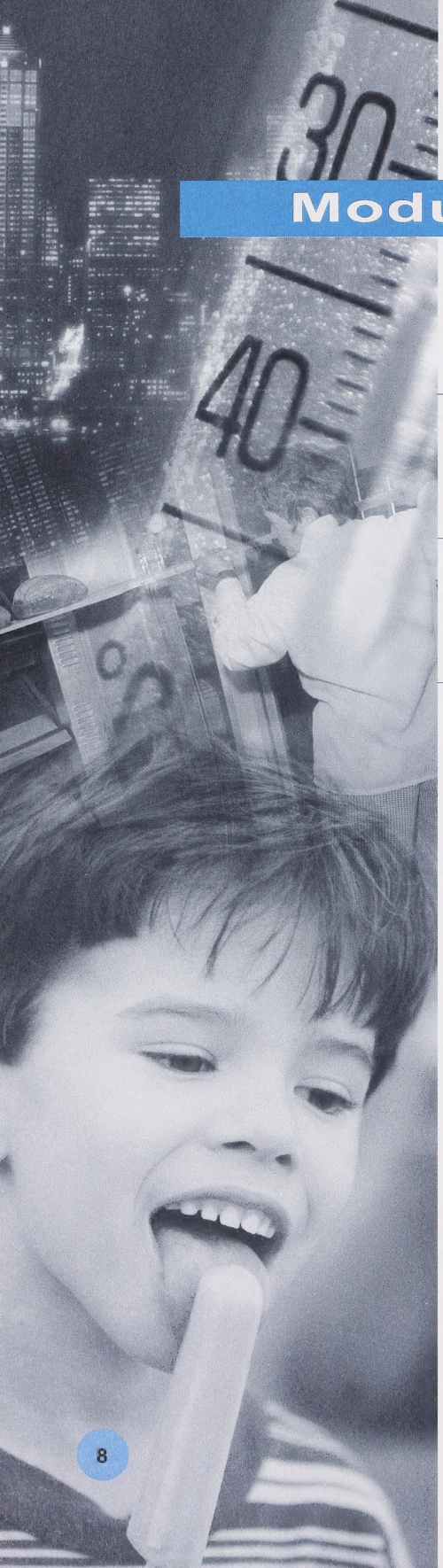
A reference is made to *ScienceFocus 7*, the textbook accompanying this course.

Internet

This is a reference to the Internet. **Note:** Any Internet website given is subject to change.

Multimedia

This is a reference to the *Science 7 Multimedia* CD.



Overview

Module 3 Heat and Temperature

Section 1
Understanding Thermal Energy and Temperature

Section 2
Effects of Thermal Energy on Matter

Section 3
Using Thermal Energy Effectively

You experience heat, or the absence of it, every day of your life. Just think, have you ever roasted a marshmallow over an open fire? Have you ever gone outside without a coat on a cold, winter day? Did you stop shivering and warm up once you got indoors?

Most people in Alberta use heat and heat technologies regularly. Often, it's without even thinking about it. Fires keep you warm when you are camping. You turn up the thermostat in the house if you get cold. You may, occasionally, be reminded to put your coat on before you go outside. You may have air conditioners to keep cool in the summer.

Humans have been generating and controlling heat since the beginning of recorded time. Until recently, they have given little thought to what happens to Earth because of the way they generate heat.

In this module you will discover what heat really is, how to explain heating and cooling, and how heat affects matter. You will also find out how to heat and how to use heat effectively. You will then deal with issues related to the use of heat energy sources.

Assessment

This booklet is the Student Module Booklet. It will show you, step by step, how to advance through Module 3: Heat and Temperature.

This module, Heat and Temperature, has three sections. Each section is built of lessons. Within the lessons, there are readings, investigations, activities, and questions for you to do. By completing these lessons, you will

- discover scientific concepts and skills
- develop a positive attitude toward science
- practise or apply these new concepts and skills

There are suggested answers in the Appendix of this Student Module Booklet. They provide you with a way to check your understanding. Your teacher will also provide you with feedback on your progress throughout the module.

At several points in this module, you will be directed to the accompanying Assignment Booklets. Your grading in this module is based on the assignments you submit for assessment. In this module you are expected to complete three section assignments and a final module assignment.

The mark distribution is as follows:

Assignment Booklet 3A	
Section 1 Assignment	36 marks
Section 2 Assignment	57 marks
Assignment Booklet 3B	
Section 3 Assignment	50 marks
Final Module Assignment	66 marks
TOTAL	209 marks

Planning Ahead

Here is a list of materials and apparatus you will need to complete this module.

Section 1

- ❑ water
- ❑ small, glass bottle with a narrow neck (e.g., pop bottle)
- ❑ drinking straw
- ❑ dishcloth (or sponge)
- ❑ ruler
- ❑ calculator
- ❑ food colouring
- ❑ modelling clay

Section 2

- ❑ long, copper or iron wire
- ❑ 200 g or 500 g hooked mass (e.g., coffee mug)
- ❑ metre-stick
- ❑ candles
- ❑ matches
- ❑ round balloon
- ❑ ruler
- ❑ string
- ❑ felt marker
- ❑ thermometer
- ❑ stirring rod
- ❑ heat source (e.g., stove, hot plate)
- ❑ 2, 250-mL beakers (or a pot and glass)
- ❑ clock or watch
- ❑ crushed ice
- ❑ water
- ❑ 2 empty pop cans
- ❑ light (at least 100 W)
- ❑ dark- and light-coloured cloth (or black and white paper or paint)
- ❑ aluminum foil
- ❑ 200 mL of cooking oil
- ❑ tape or rubber bands
- ❑ plastic (e.g., from a pen)
- ❑ copper wire
- ❑ long, iron nails
- ❑ wooden craft sticks (or pencils)
- ❑ ice cubes
- ❑ various insulating materials

Section 3

- ❑ 2 identical glass jars
- ❑ water
- ❑ 10 ice cubes
- ❑ clear, glass lid (or clear, plastic bag)
- ❑ thermometer
- ❑ 3 tin cans (284 mL)
- ❑ newsprint
- ❑ masking tape
- ❑ heat source (e.g., stove, hot plate)
- ❑ 500-mL beaker (or a small pot)

If you have access to the Internet, you may want to check out some of the links for this module ahead of time. Go to the following site:

http://www.mcgrawhill.ca/school/booksites/sciencefocus+7/student+resources/toc/index.php

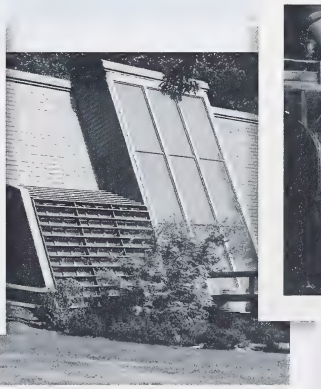
Section 1

Understanding Thermal Energy and Temperature

Throughout history, humans have had two main purposes for heat. One was to keep warm, especially in a cold climate. The other was to prepare food, such as bread. Now, heat is used for many more things. For example, collecting energy to run a household and making steel.

But not all heat is beneficial to humans. Just think of the last time you burned your finger on something hot. Heat that is released from something that is hot or burning can either be controlled or uncontrolled. If heat is controlled, as in a furnace, it can be a benefit. If heat is uncontrolled, as in a house fire or explosion, it can do a lot of damage. Uncontrolled heat is not likely a benefit.

In this section you will discover how people have learned to control heat and to use heat to meet their needs. You will make your own thermometer and look at other temperature-measuring devices. You will then use the particle model of matter. It will help you to explain how heat and temperature are related.



Lesson 1: Using Energy from Heat

Doesn't this look like a great place to keep warm? People survive in harsh conditions because they know how to produce and control heat energy.

People from different cultures and times have used different methods of keeping warm. Discovering different ways of keeping warm has allowed people to travel out of warm areas. People have been able to travel to and settle in most areas of the world. This is because they knew about heat production and control.

Settlers, for example, stayed warm on the prairies by building a "soddie," or a sod house. (Refer to Figure 3.1F on page 188 of the textbook to see what a soddie looked like.) Soddies were made by breaking the earth into chunks of grass and dirt. These chunks were stacked, like bricks, to form walls. The roof was also made of sod. It was supported by local trees or beams taken from the settler's wooden wagons. Soddies kept the occupants cool in the summer and warm in the winter. However, they could be very damp in the wet seasons.

Can you imagine living in a house built of sod? The settlers relied on body heat and small cooking stoves to keep the inside of the soddie warm in the winter. The sod house made life for the early immigrants a little more comfortable.

Read the introductory information on pages 184 to 188 of the textbook. It will focus your mind on the uses, controls, and technologies of heat.

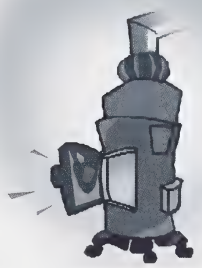
Going Further

Making informed decisions is a very important skill for members of society. Read "Looking Ahead" on page 187 of the textbook. It gives you ideas to prepare you for your own issue analysis—issues you will find near the end of Section 3.

Investigation 3-A Using Energy

Read the investigation on page 189 of the textbook.

What forms of energy are used to produce heat in your home? Would your next-door neighbour's home, a public building, and a cottage in the wilderness use the same form? Survey the people in your neighbourhood to get some answers. Read "Think About It." Then scan the steps in "Procedure."



If possible, have your friends, family, teacher, or home instructor participate in the activity. If you do this investigation on your own, you may still want to find a partner. It's easier with someone to help when visiting various sites to gather data. You cannot survey as many sites as a classroom filled with students can. Visit at least three different locations, like your school, library, a friend's home, hospital, or local business. Talk to homeowners or the facility operators of larger buildings.

Note: Write all your answers to the questions in this course in a notebook. It will help when you need to review a certain topic.

1. Do questions 1 and 2 of "Analyze."

Check your responses with your teacher or home instructor.

end of investigation

Going Further

Do all provinces use the same energy sources? Do some use one source more than others? Find out by answering the questions posed in "Extend Your Knowledge" on page 189 of the textbook.

Using Heat

Heating homes is only one aspect of heat technology that has changed over the years. The next question deals with other changes involving heat technology. Read "More Uses of Energy" on page 190 of the textbook before answering question 2.

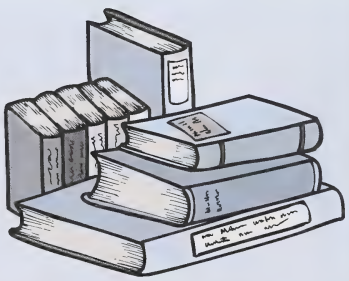
2. Copy and complete the following table in your notebook. You will find a number of tasks that people have done for years. In the first column, describe how you think a prairie family carried out each of these tasks 100 years ago. In the second column, describe how a prairie family would do the same task today. If you are not sure of some of the methods, imagine how you would do these tasks without electricity or a central heating system. Plan your table so the boxes are sized to fit the information they will contain. **Hint:** It is often easier to use a computer to prepare tables.

Considering Change		
Task	**How Task Was Accomplished 100 Years Ago**	**How Task Is Accomplished Today**
washing clothes		
drying clothes		
warming leftovers		
drying hair		

Compare your response with the one in the Appendix, page 97.

Going Further

Do some research using your local library or the Internet. Find out how heat technology is used in industry. Do "Find Out Activity: How Was It Made?" on page 191 of the textbook.



You have now completed the concepts for this lesson. To review what you studied, do the following question.

3. Turn to page 191 of the textbook. Answer question 1 of "Topic 1 Review."

Check your response with your teacher or home instructor.

Looking Back

Living in Alberta, you already have a good appreciation for heat! You learned about the way settlers used and controlled heat. Likely, you prefer the modern ways of heat production and control, not to mention all the products and conveniences that modern heat technologies have created.

In this lesson you conducted a survey. You found how people use heat technologies today in a variety of settings. You also saw how everyday tasks were completed many years ago. New technology has made things much easier. Before you proceed to the next lesson, pause a moment. Try to imagine how people will cook their food and warm their homes 100 years from now.

Turn to page 1 of Assignment Booklet 3A and answer questions 1, 2, and 3.

Lesson 2: Measuring Temperature

When you have a shower or bath, do you feel the water with your hand or foot before climbing in? By doing this, you can tell if the water is too hot, too cold, or just right. When you are sick, does someone try to guess your temperature by placing his or her hand on your forehead? How accurate are your senses? Can your sense of touch be fooled? You will find out in this lesson. You will also investigate the history of temperature scales, and you will explain how modern technologies help people measure and control heat.

Temperature

If someone says "It's hot!," is it? If it is 2°C outside in winter, do you think it's warm? What about in the summer? If it's 2°C outside, do you think it's warm? The **temperature**, measured on the Celsius scale, is exactly the same! But your interpretation of the temperature is certainly very different. What exactly is temperature? How can temperature be measured and communicated?

Turn to page 192 of the textbook. Read the introductory information of "Topic 2: Measuring Temperature." This will get you thinking more deeply about sensing and estimating temperature.

1. a. Classify each statement as being qualitative or quantitative. (**Hint:** Refer to "Skill Focus 6" on page 458 of the textbook.)

   Statement A: The bath water is warm.

   Statement B: The bath water is 25°C.

   b. Which piece of information is more reliable? Explain.

2. List two ways you can estimate temperatures with your senses.

3. What were the record Canadian high and low temperatures at the time the textbook was published?

Compare your responses with those in the Appendix, page 97 and 98.

Find Out Activity Baffle Your Skin

Read the activity on page 193 of the textbook.

This fun and amazing activity makes a great party trick. It's incredible how wrong your senses can be! Read through the activity. Then follow the steps of the procedure. You can add some ice to the cold water for an even greater effect.

Be very careful. Make sure the hot water from the tap will not burn you.

4. Are you surprised at your results? Now answer question 1 of "What Did You Find Out?"

Compare your response with the one in the Appendix, page 98.

Measuring Devices

What did you learn in the previous activity? Do you think it is a good idea to estimate temperatures by touch? Not only can your skin be fooled, at times it can be dangerous. (For example, a very hot, glass beaker generally looks the same as a cool one.) Also don't forget that your idea of hot, cold, or warm varies from situation to situation. Even your friends and family will disagree from time to time. For these and other reasons, an accurate, dependable device for finding temperatures is needed. This device is called a the **thermometer**.

The history of the thermometer is interesting. Galileo made the first thermometer about 300 years ago. The next improvement took place about 100 years later. A usable **scale** was developed. This made the thermometer even more useful.

Turn to pages 193 to 195 of the textbook. Read "Thermometers" and "Temperature Scales." You will gain an understanding of how and why the two most common temperature scales were developed. Answer the following questions based on those readings.

5. Write a definition for each of the following terms:

   - *thermometer*
   - *scale*
   - *Kelvin scale*

6. The Celsius scale is the most popular temperature scale used in the world today.

   a. What point did the inventor choose to represent 0°C on this scale?

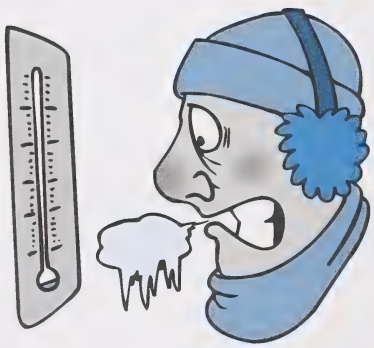
   b. What point did the inventor choose to represent 100°C on this scale?

   c. How did the inventor calibrate the scale?

7. Name two factors that affect the boiling and freezing points of water. Explain.

8. List three differences between the Celsius scale and the Kelvin scale.

Compare your responses with those in the Appendix, page 98.



There is an expression, "Necessity is the Mother of invention." Maybe you have heard it. Well, people found it necessary to tell others what the measured temperature was. Lots of inventions came from this necessity. For example, during the 1880s, the Sourdough Thermometer was used in the far north. Store-bought thermometers were far too fragile for the lifestyle of that time and area. The Sourdough Thermometer was created from items commonly found in homes and backpacks. The thermometer consisted of a row of four bottles. Each bottle had a different content: mercury (gold dust extractor), coal oil (lantern fuel), extract of ginger, and Perry Davis' Painkiller (almost pure alcohol). They were set up outside a window. Mercury froze at about – 40°C; coal oil froze at – 50°C; and the extract froze at about – 60°C. The painkiller turned white at – 60°C, crystallized at – 70°C, and finally froze solid at – 75°C. Stagecoaches did not travel when the painkiller froze to slush.

Now you get to build your own thermometer from common household materials!

Investigation 3-B Make Your Own Thermometer

Turn to pages 196 and 197 of the textbook. Read through the entire investigation. Do this before you begin building your thermometer. Follow the guidelines. Change your design as needed to fit your materials. Check your plan with your home instructor.

Now, it's time to start building.

9. Answer questions 1 and 2 of "Evaluate" in Part 1 of the investigation.

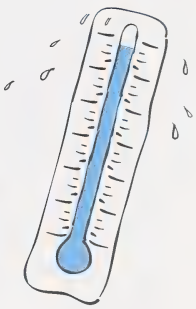
10. Answer questions 1, 2, and 3 of "Evaluate" in Part 2 of the investigation.

Check your responses with your teacher or home instructor.

end of investigation

Investigation 3-C Boiling Hot, Freezing Cold

This investigation is a matching game. You try to match measured and estimated temperatures with an event or situation. First, identify any temperatures that you know. Complete the rest of the table using common sense and educated guesses. Don't worry if you make a mistake. Just do your best before checking your work. If you are working at home, you may ask family members for their thoughts. It could be fun to sit down with them and see who can get the most correct. Have fun!



11. Do Investigation 3-C on page 198 of the textbook. **Note:** You do not need to do steps 1 or 2 of the procedure. Just number your paper from 1 to 18, and write the temperature beside the number.

Compare your response with the one in the Appendix, page 99.

end of investigation

Temperature Devices

You have looked into the history of the thermometer and the two common scales. Now, read about a variety of temperature instruments that are used for different purposes. Each of these instruments uses a **sensor**, a **signal**, and a **responder**.

Turn to pages 199 to 201 of the textbook. Read "The Right Device for the Job."

12. Complete the following table. Identify the sensor, signal, responder, and purpose for each device. An example has been done for you. Plan your table so everything fits well.

sensor: a device or material that is affected by changes in some feature of the environment, such as temperature

signal: a physical quantity, such as electric current, used to transmit information

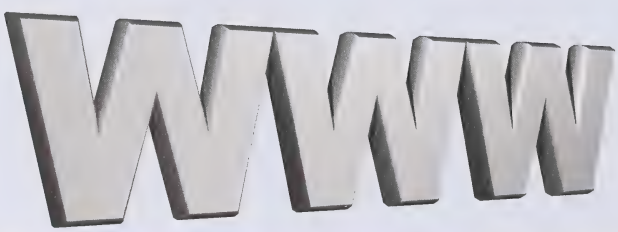
responder: a pointer, light, or other mechanism that uses the signal in some way

Temperature Devices				
Device	**Sensor**	**Signal**	**Responder**	**Use**
thermocouple	**copper and iron wires**	**electrical current**	**switch or valve**	**measures very high temperatures**
bimetallic strip				
recording thermometer				
infrared thermogram				

Compare your response with the one in the Appendix, page 100.

Going Further

If you have Internet access, find out more about "hot stuff" by doing the "Internet Connect" on page 201 of the textbook.



You have now completed the new concepts for this lesson. To review what you covered, do the following questions.

13. Turn to page 201 of the textbook. Answer questions 1, 2, 4, and 5 of "Topic 2 Review."

Check your responses with your teacher or home instructor.

Looking Back

Once again you have choices. You can choose to estimate with your own senses, but can they really be trusted? You can also choose to take a precise measurement. There are devices designed and calibrated for most purposes.

In this lesson you reviewed the history of thermometers. You studied a variety of temperature scales of varying accuracy. You were also introduced to several modern devices. These devices sense, measure, monitor, record, and control temperatures—including those in your own body.

Turn to pages 2 and 3 of Assignment Booklet 3A and answer questions 4 to 8.

Lesson 3: The Particle Model, Temperature, and Thermal Energy

You're sitting around a roaring campfire with family and friends. The night is cold and so is your back, but the part of your body facing the fire is toasty warm. You then start thinking about the fire and the heat. What's behind these phenomena? How does the heat from the fire get to you? Why is your back so cold?

These are all good questions! Questions you will explore in this lesson. You will use a model (or representation) of matter to help you get at the nature of thermal energy and how it differs from temperature.

The Particle Model of Matter

The **particle model of matter** explains the make-up of all matter. Many scientific concepts are based on this model. This model is introduced on pages 202 and 203 of the textbook. Read this introduction.

1. Write definitions for the terms *particle model of matter* and *matter*.

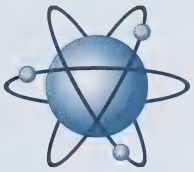
2. How many particles are in a drop of water?

3. According to the particle model of matter, air is made up of particles in motion. Why don't you feel these particles hitting your skin?

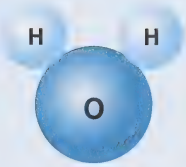
Compare your responses with those in the Appendix, page 101.

DID YOU KNOW?

Atoms make up the particles of the particle model.



The diagram on the left is a simple model of an atom. An atom is the smallest unit of matter. They are so small that they are invisible. Atoms are the building blocks of the particles in the particle model of matter. The diagram on the right is a model of a water particle. It is comprised of two hydrogen (H) atoms and one oxygen (O) atom.



You know what solids, liquids, and gases are. But what makes them a solid, liquid, or gas? How does energy fit into the picture? The next activity will focus your thoughts on how the particle model explains the three states of matter.

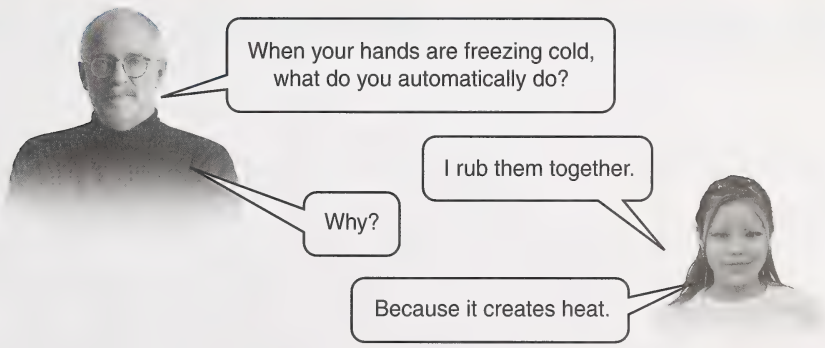
Find Out Activity Pouring? Shaping? Filling?

Read the activity on page 202 of the textbook. Study the diagrams very carefully.

4. Answer questions 1 and 2 of "Procedure."

5. Answer "What Did You Find Out?"

Compare your responses with those in the Appendix, page 101.



Tara has found a connection between a rubbing motion and heat. Do you think the particle model of matter can explain this?

Find Out Activity Detect a Connection

Read the activity on page 203 of the textbook. Pay special attention to the pictures provided.

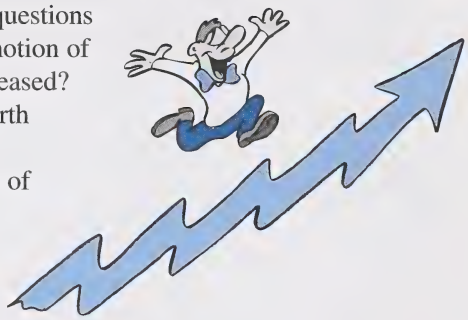
6. Answer questions 1, 2, and 3 of "Procedure."

7. Answer questions 1 and 2 of "What Did You Find Out?"

Compare your responses with those in the Appendix, pages 101 and 102.

Explaining Temperature

What did you learn from the diagrams and questions in the last activity? Did you see that if the motion of the particles increased, the temperature increased? If you did, good job! This is, in fact, the fourth point of the particle model and is stated as follows. (The first three points are at the top of page 203 in the textbook.)



The more energy particles gain, the faster they move.

Think about it! This statement makes a lot of sense! You move more when you have a lot of energy, don't you?

But what is energy? More specifically, what is heat energy?

Many years ago, scientists thought that heat was a fluid that, although invisible, had mass. They called this substance caloric. (You may have heard people talk of the number of calories in a certain food. Now you know where the name came from.) According to these scientists, the substance—caloric—moved from a hot material into a cold material. It stood to reason that a beaker with 100 mL of 80°C water in it would have more mass than 100 mL of water at 20°C. For hundreds of years, this was assumed to be true until it was tested with the more precise balance scales that became available. Surprise surprise, no difference in the masses was found. (Modern devices would in fact find the 80°C water to be lighter.)

Scientists now believe that heat is a form of energy. Energy has no mass. Remember that every tiny particle has a tiny bit of energy. An object is made of multitudes of tiny particles. Their average energy can be measured with a thermometer. Temperature is an indicator of the average thermal (heat) energy of the particles in a substance. The more energy the particles have, the faster they move. This gives a higher reading on the thermometer.

Turn to page 204 of the textbook. Read "Temperature and the Particle Model" and the information in both "Did You Know?" boxes.

8. Define the term *temperature*.

Compare your response with the one in the Appendix, page 102.

Ms. Burton: Do you see any attraction between these people?

Austin: I'm not sure what this has to do with science, but the smiles indicate some sort of attraction. I'd say they look like friends.

Ms. Burton: I agree. Did you know, in science, there are also forces of attraction between particles of a substance. This force may be strong or it may be weak.

The fifth statement of the particle model of matter is as follows:

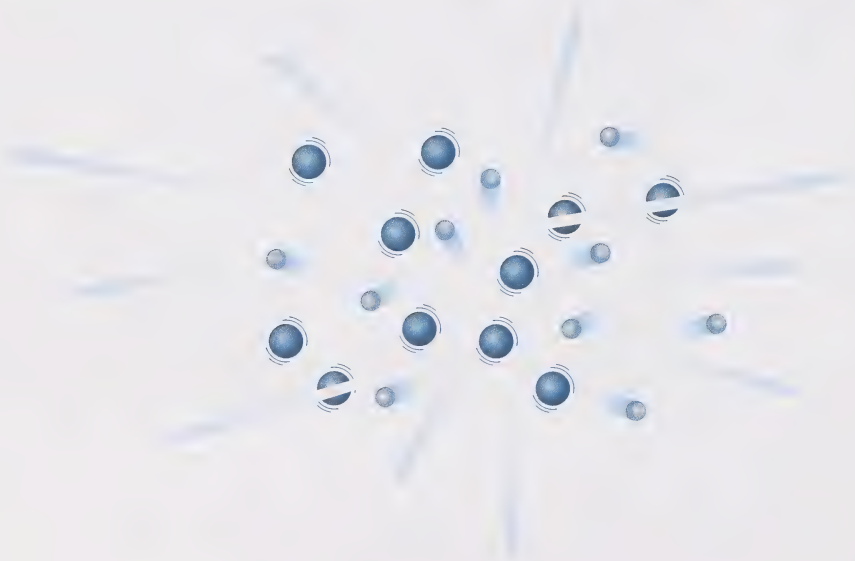
> *There are attractive forces between the particles. These attractions may be strong or weak.*

Do you remember the second "Did You Know?" box on page 204 of the textbook? It says why the strength of these attractive forces is important. The strength of these attractive forces relates to characteristics of materials that you can observe, like state and solubility.

Attractive forces hold substances together. If the attractive force between two substances is strong, one substance will dissolve into the other. Sugar and water particles are strongly attracted to each other, so sugar dissolves into water. (The sugar breaks up into separate particles and diffuses into the spaces between the particles of water.)

If the attractive force within a substance is stronger than the attractive force between two substances, the particles will not dissolve. They will remain clumped. For example, the attractive forces between oil and water are weak, so they do not mix.

These attractive forces are also an important factor in changes of state. Remember, it is attractive forces that hold matter together. As particles gain more and more energy, the particles move faster and faster. They hit each other harder and harder. If a particle gains enough energy, it can break away from the attraction of the other particles. As it frees itself, it changes state (solid to liquid or liquid to gas).



Note: You will deal with changes of state again later in this module.

The opposite is also true. As particles lose energy, they move more slowly and get closer together. The attraction between the particles at some point overcomes a particle's energy level. It is captured by the group and changes state in the process (gas to liquid or liquid to solid).

Defining Energy

Mikaila: What is energy?

Mr. Casey: Energy is defined as the ability to do work.

Mikaila: So, just what does that mean and how does it relate to heat and temperature?

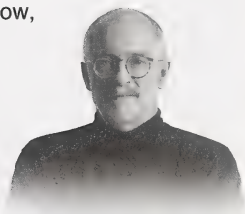
Mr. Casey: Let's look at specific examples. It takes energy to lift a rock; lifting the rock is work. It takes energy to keep a car going at highway speeds. That's why the gas gauge goes down when driving from Calgary to Edmonton. The energy used to move the car is stored in the chemicals of the fuel that is burned in its engine. The engine then moves the car. So, in this case, work is done (the car is moving) using the chemical energy released from the fuel.

Mikaila: What about a baseball hit to the outfield? Does it really have energy? It does not have any fuel to keep it going.

Mr. Casey: Yes, the baseball has energy simply because it's moving. Such energy is called kinetic energy.

Mikaila: Does this mean that even particles of matter have kinetic energy, too? If so, they are so small that they shouldn't have much.

Mr. Casey: You have made an interesting connection. You are right that each individual particle would not have much kinetic energy. They're just too small. Now, add up all the kinetic energy of all the particles in a visible object. You now have a lot of energy. This total kinetic energy of the particles is known as the thermal energy of the substance.



Mikaila: I see. When an object gets warmer, its particles move faster. Hmm . . . that means they all gain energy . . . well . . . kinetic energy. That also means the total kinetic energy of the object increases. In other words, the thermal energy of the substance goes up with temperature.

Mr. Casey: Well done.

Turn to pages 204 and 205 of the textbook and read "What Is Energy?" It expands on the ideas just discussed.

9. Write definitions for the following terms:

- *kinetic energy*
- *thermal (heat) energy*
- *joule*

10. There are two identical cups containing 100 g of water. The water in one is at 20°C. The water in the other is at 80°C.

    a. How does the number of particles in each cup compare?

    b. How do their thermal energies compare? **Remember:** For each cup, the thermal energy is the total energy of all the particles in the cup.

11. List the two rules of energy transfer.

Compare your responses with those in the Appendix, page 102.

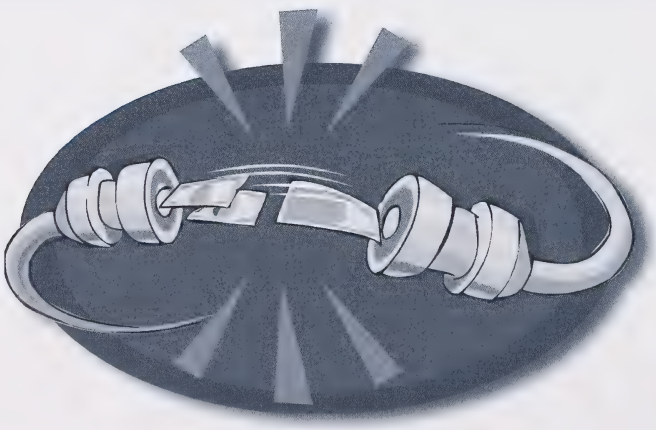
Thermal Energy and Temperature

Turn to pages 206 and 207 of the textbook. Read "Thermal Energy and Temperature Changes." It explains how thermal energy and temperature are related.

12. a. You need to increase the temperature of the water in Lake Superior by 1°C. Would you need to add a little or a lot of heat energy? Explain.

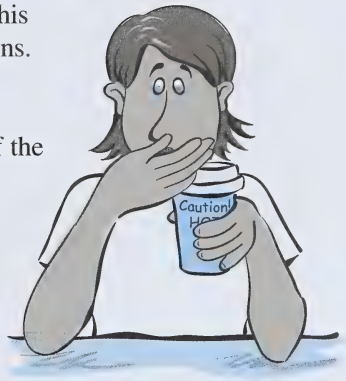
    b. You need to increase the temperature of a bucket of Lake Superior water by 1°C. Would you need to add a little or a lot of heat energy? Explain.

Compare your responses with those in the Appendix, page 102.



Find Out Activity Soup in a Cup

Have you ever burned your tongue on hot soup? This activity should help you determine why that happens. Do you remember the following?



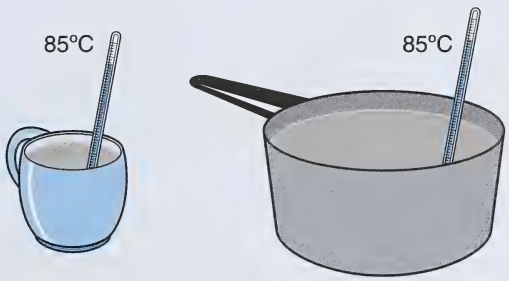
- Temperature is the **average** kinetic energy of the particles in a substance.
- Thermal (heat) energy is the **total** kinetic energy of all the particles in a substance.

Temperature only reflects how fast the particles are moving. Thermal energy reflects how fast the particles are moving as well as the number of particles in the substance or object.

Procedure

Part A

Consider the following diagrams. One is a small cup of chicken broth; the other is a large pot of the same chicken broth. Both are at 85°C.



13. Use the diagrams to answer the following.

    a. Compare the thermal energy in both diagrams. Explain.

    b. The particles in both the pot of soup and the cup of soup have the same average kinetic energy. How do you know this?

    c. In each diagram, energy is being transferred to the air. What does that do to the speed of the air particles? What does it do to the speed of the soup particles?

Check your responses with your teacher or home instructor.

Part B

Now, consider this situation. Four cups have exactly the same amount of chicken broth. Each cup is at a different temperature.

14. Use the diagrams to answer the following.

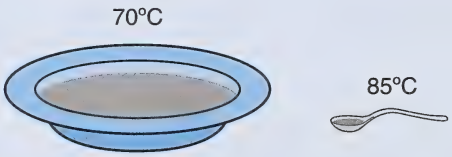
    a. Compare the average energy of the cups of chicken broth. Explain.

    b. Which sample contains the most thermal energy? Why?

Check your responses with your teacher or home instructor.

Part C

Now, consider the following diagrams. A bowl of chicken broth is at 70°C. A teaspoon of the same chicken broth is at 85°C.



15. Use the diagrams to answer the following.

    a. Which has the greater average kinetic energy? Why?

    b. Which of the samples has the greater total kinetic energy? Why?

Check your responses with your teacher or home instructor.

What Did You Find Out?

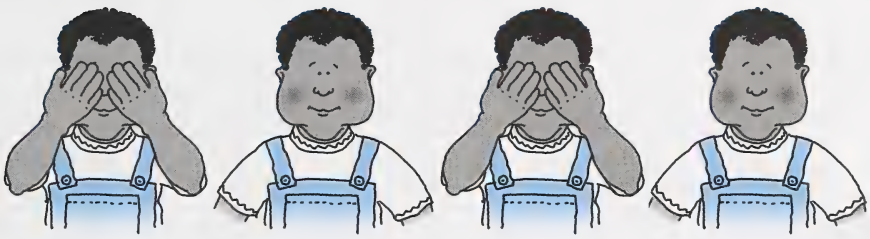
Now, it's time for you to answer the final question: Why does hot soup burn your tongue? To help you with this, answer the following.

16. a. Which of the substances shown—the chicken broth or the tongue—has a higher temperature?

    b. Which direction does heat energy move?

    c. Why can you burn your tongue with hot soup?

Check your responses with your teacher or home instructor.



As a toddler, you learned that most things continue to exist even when you can't see them. They don't magically disappear into thin air or come from nowhere. This applies to energy as well. Scientists have stated it clearly in the particle model of matter.

Turn to page 207 of the textbook. Read "What Energy Is . . . and Is Not." You will learn about the Law of Conservation of Energy. It is the sixth and final statement of the particle model.

You have now completed the new concepts for this lesson. Review what you covered by doing the following questions.

17. Turn to page 208 of the textbook. Answer questions 2, 3, 4, 6, and 7 of "Topic 3 Review." **Note:** Question 3 should read, "Describe two situations in your life in which **energy** caused changes in something."

Check your responses with your teacher or home instructor.

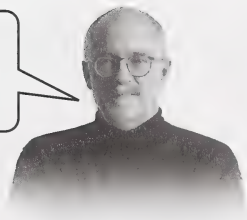
Looking Back

In this lesson you studied the particle model of matter. You used it to tell what being at different temperatures means. The major concept of this lesson is something that you know from daily experience. Heat moves from areas of high temperature to areas of lower temperature. (Thermal energy moves from a substance with a higher average kinetic energy—higher temperature—to one with a lower average kinetic energy—lower temperature.) You were also introduced to three forms of energy: chemical energy, kinetic energy, and thermal energy. The focus of the lesson was thermal energy.

Turn to page 4 of Assignment Booklet 3A and complete questions 9 and 10.

Section 1 Review

The following "Wrap-up: Topics 1–3" questions on page 209 of the textbook will help you review and apply the work you did in this section.



1. Answer question 1 of "Reviewing Key Terms."

2. Answer questions 2, 3, 4, 7, and 9 of "Understanding Key Concepts."

Check your responses with your teacher or home instructor.

Conclusion

In this section you discovered how people control and use heat. You made your own thermometer to measure temperature and investigated other temperature-measuring devices. You used the particle model of matter to explain heat and temperature.

You discovered that a useful heat source is a controlled source. A thermostat is a device that controls a heat source automatically. The thermostat in your home controls the furnace. By controlling the furnace, you can have the furnace produce just enough heat. The result—your home stays at just the right temperature. It was the understanding of heat and temperature that helped people design thermostats.

Turn to page 5 of Assignment Booklet 3A and complete questions 11, 12, and 13.

Section 2

The Effects of Thermal Energy on Matter

Have you ever noticed that telephone wires and power lines sag more in the summer than in the winter? It is as if the lengths of the wires change over the seasons. In fact, the lengths of the wires do change. The wires get a bit longer as the temperature rises with the approach of summer. This change in length may seem strange to you; but if you apply the particle model of matter, you will see why temperature has this effect on the wires.

In this section you will apply your knowledge of the particle model and heat energy to a variety of real-life situations. You will examine why matter expands or contracts as heat is added or removed. You will look more deeply into the part particles play in the three states of matter. You will then discover how heat energy can be transferred from one location to another. Finally, you will see that energy can be transformed from one type to another.

Lesson 1: Expansion and Contraction

Have you ever thought about why trains make a thunking noise as they pass by? The reason is good planning! That thunking noise is made when the wheels of the train pass over expansion joints. Like telephone wires and power lines, railroad tracks also expand and contract with the changing temperature. So, these expansion joints are placed periodically along the tracks, allowing the tracks to move (expand and contract). Without these joints, the tracks would bend up or sideways to give them the room they need to move. Would you want to be on a train that's going down crooked tracks?

You will learn more about this in this lesson. You will apply your understanding of the particle model to explain the **expansion** and **contraction** of substances and objects.

Changing Volume

Have you ever taken a filled balloon outside in cold weather? If you have, you probably noticed that it gets small and wrinkly. The gas particles inside the balloon lose heat energy to the air. They move closer together making the balloon contract (get smaller).

Suppose you pumped a balloon up to its maximum size using cold, outside air. What do you think would happen if you took it inside?

Kaboom! As the gas particles in the balloon absorb heat energy from the air inside, they move faster. They hit each other harder and move farther apart. This causes the balloon to get larger.

In both cases, the size (volume) of the balloon changes. The balloon responded to the temperature of the particles in the balloon. The changes in volume caused by changes in temperature are referred to as **thermal expansion** and **contraction**.

Turn to page 210 of the textbook. Read the introductory paragraphs of "Topic 4: Expansion and Contraction." Then read "Expansion and Contraction of Solids" on page 211. You will find out more about thermal expansion and contraction.

1. Define the following terms:

   - *expansion*
   - *contraction*
   - *compress*
   - *volume*

2. Copy and complete the following table.

Comparing States of a Given Substance				
State of Matter	**Volume**	**Shape**	**Compressibility**	**Average Energy Level**
solid	**definite**			
liquid		**indefinite**		
gas			**compressible**	

3. Why does the table in question 2 refer to a given substance?

4. Answer questions a. and b. of "Pause and Reflect" on page 210.

Compare your responses with those in the Appendix, page 103.

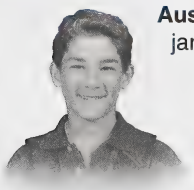
Find Out Activity Stretch and Shrink

Read the activity on page 211 of the textbook.

5. Answer question 1 of "Procedure."

6. Answer question 1 of "What Did You Find Out?"

Compare your responses with those in the Appendix, page 104.



Austin: Hey Tara, can you help me? I can't get the lid off this jar.

Tara: It'll be a snap.

Austin: Where are you going? Why are you walking toward the sink? What's with the hot water?

Tara: My grandma always runs hot water over a lid before she tries to take it off.

(Pop! Tara gets the lid off.)

Tara: See, it's real easy.

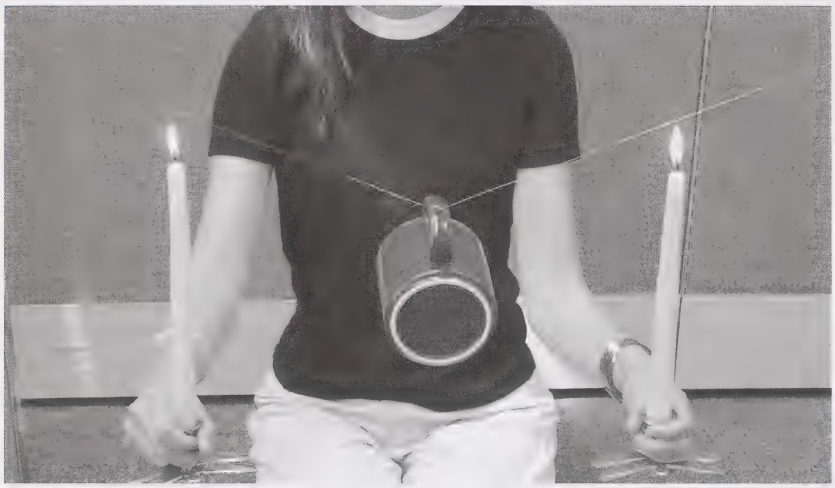
Austin: Wow! That's a neat little trick.

Do you know why the hot-water trick worked? The next investigation should clear up the mystery.

Read the entire investigation on pages 212 and 213 of the textbook.

Part 1: The Sagging Wire

Read through the information on page 212. **Take careful note of the safety precautions.** Modify the equipment (with your home instructor's guidance). Make it suit your situation. For example, use a coffee mug for the weight. Thread the wire through the handle.



In your notebook, copy the following table. Follow the procedure with your home instructor present. Enter your results in the table.

Effect of Heat Absorption on Metal Wire	
Time (s)	**Height of Weight (cm)**
0	
30	
60	

7. Answer questions 1, 2, and 3 of "Analyze" on page 212 of the textbook.

Check your responses with your teacher or home instructor.

Part 2: The Ball and Ring

If you have access to a ball-and-ring apparatus, follow Path A. If not, follow Path B. In either case, answer question 8.

Path A

Do steps 1 and 2 of the procedure on page 213 of the textbook. Your home instructor will perform steps 3 and 4. They will also do any necessary procedures for step 5 as a demonstration.

Path B

The following is a description of what a student observed after following the steps of the procedure:

> *When cold, the ball does not fit through the ring. When only the ring is heated (step 3), the ball passes easily through the ring. When both the ball and the ring are heated, the ball no longer passes through the ring. When the ball is placed in the ring and they are both allowed to cool (step 5), you cannot separate them. (The ball is too large to fit through the ring.) They can only be separated again by heating only the ring or placing only the ball in ice water.*

8. Answer the following on page 213 of the textbook.

   a. questions 1 to 4 of "Analyze"

   b. question 5 of "Conclude and Apply"

Check your responses with your teacher or home instructor.

end of investigation

Heat and the Gaseous State

Did you ever come home just before supper and have the delicious smell of your meal welcome you? You probably didn't even have to go into the kitchen to see what was on the stove. The odour—an invisible gas—told the story.

Turn to page 214 of the textbook. Read "Expansion and Contraction in Gases." You will find out more about gases. You will be introduced to the fourth state of matter—plasma—when you read "Off the Wall."

9. Answer questions a. and b. of "Pause and Reflect."

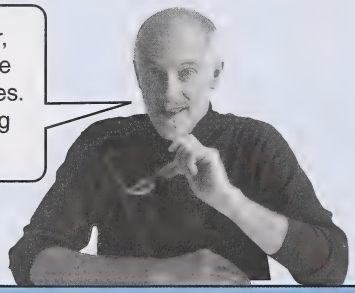
10. What is plasma?

Compare your responses with those in the Appendix, page 104.

In Investigation 3-D: Expanding Solids, you observed expansion and contraction in a solid. Next, you will investigate the effects of increasing the thermal energy of a sample of air. The air will be in a balloon. Changes in the size of the balloon will indicate expansion or contraction of the gas inside.

Find Out Activity Expansion and Contraction of Gases

If you can, get help from a friend, family member, or your home instructor. You will be measuring the circumference of a balloon at different temperatures. Prepare for the steps of the procedure by copying the following table into your notebook.

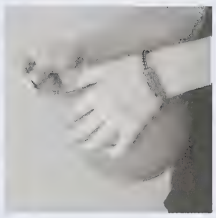


Contraction and Expansion of Air	
Condition of Balloon	**Circumference (cm)**
room temperature	
freezer	
exposed to hot tap water	

Materials

- round balloon
- ruler
- string
- felt marker

Procedure



step 1: Blow up the balloon until it is full, but not totally full, of air. Tie the balloon securely, making sure no air can escape.

step 2: Take the string and wrap it around the middle of the balloon. You will be measuring its circumference (distance around the outside). Use the felt marker to draw a line around the balloon to show where the string was wrapped.

step 3: Mark the string at the point where it completes one wrap around the balloon. Unwrap the string and measure the marked distance (the circumference of the balloon). Record this measurement.

step 4: Carefully put the balloon in a freezer for 5 minutes. (You can put it outside if the temperature is below 0°C.)

step 5: Gently remove the balloon from the freezer. (A cold balloon can be very fragile.) Then quickly repeat step 3.

step 6: Hold the balloon under hot tap water in a sink for one minute. **Be careful. The water may be hot enough to burn you.**

step 7: Gently remove the balloon from the water. Then quickly repeat step 3.

What Did You Find Out?

11. a. What happened to the circumference of the balloon when it was cooled below room temperature? What is this observation evidence of?

    b. What happened to the circumference of the balloon when it was heated above room temperature? What is this observation evidence of?

    c. Explain your observations using the particle model of matter. (Refer to your concept diagram. Explain what the particles are doing and why.)

Compare your responses with those in the Appendix, page 104.

Turn to page 6 of Assignment Booklet 3A and answer questions 1 and 2.

Changing the Volume of Liquids

Ms. Burton: Back to thermometers! You know they are used to measure temperature. Do you remember what temperature is? It's the average kinetic energy level of the particles in a substance.

Miguel: But how do thermometers work? I already know that solids and gases expand when they absorb heat energy. I also know that their volume decreases when they lose thermal energy. Is the red fluid in the thermometer affected by temperature in the same way?

Ms. Burton: Think about the red fluid in the thermometer. What does it do when you put it into or against a hotter substance?

Miguel: It rises up the tube.

Ms. Burton: Yes, it expands up the narrow tube. The hotter the liquid gets, the further it expands up the tube. When the thermometer is placed in a colder substance, the opposite occurs.

Miguel: But wouldn't the air above the red liquid get in the way?

Ms. Burton: Actually, almost all the air is removed during the manufacturing of a thermometer. There's a vacuum above the liquid. The lack of air allows the fluid to go up and down freely. The tube of the thermometer is marked to form a scale. The thermometer is marked in 1°C steps. Each 1°C change causes the red liquid to expand or contract enough to move the distance between the marks.

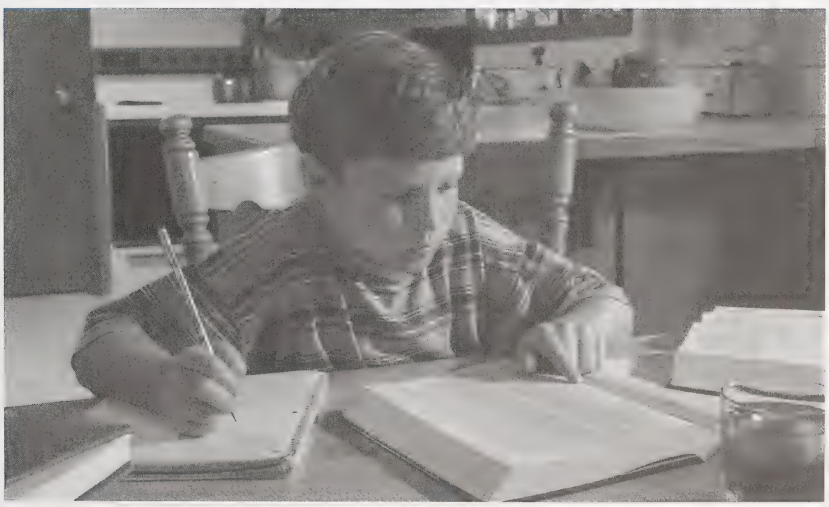
Miguel: So, the tube of the thermometer is kept thin so you can see the liquid expand or contract more easily?

Ms. Burton: Yes. A temperature change drives a change in volume of the fluid. The fluid moves in the bore, or hollow part of the tube. If the bore is small, it will take only a small amount of fluid to fill a large part of the tube. Thus, a thermometer with a small bore makes a temperature change easier to see. Of course, if you make the bore extremely small, the scale would have to be made extremely long. This is not very good if you want a compact thermometer.

Turn to page 215 of the textbook. Read "Expansion and Contraction in Liquids."

12. What is the thin vacuum (airless) tube in the centre of the thermometer called?

Compare your response with the one in the Appendix, page 104.



Find Out Activity Race for the Top

Read the entire activity on page 216 of the textbook.

Now, re-read the first paragraph and study the diagram. Write your hypothesis.

Do you have access to the materials listed in the activity? If so, do **Part A**. Otherwise, do **Part B**.

Part A

Follow the procedure carefully. Be sure your home instructor is directly supervising you. You can do the activity using only cooking oil and water.

If you do test alcohol, do not use an open flame. Alcohol fumes are very flammable.

Once you have gathered your data, answer question 13.

Part B

Review the procedure in the activity. The following table holds data another student obtained. Use it to answer question 13.

Expansion of Liquids

Liquid	Final Height Above Rubber Stopper (cm) (hot water in beaker)	Final Distance Below Rubber Stopper (cm) (cold water in beaker)
A	3	1
B	1	0
C	5	3

13. Answer questions 1, 3, and 4 of "What Did You Find Out?"

Compare your responses with those in the Appendix, pages 104 and 105.

14. Turn to page 217 of the textbook and answer questions 1, 2, and 3 of "Topic 4 Review."

Check your responses with your teacher or home instructor.

Looking Back

Ka Thunk! Ka Thunk! Ka Thunk! Ka Thunk! That's the sound of a good railway design. You know that the sound is especially important in Canada. It is the sound of the train wheels hitting expansion joints. They come between the sections that allow the track to expand and contract as temperature changes. These can be large even from day to day, not to mention season to season.

In this lesson you were introduced to the terms *expansion* and *contraction*. You investigated whether matter expanded or contracted with changing temperature. You observed that gases, liquids, and solids expand when heated. Gases expanded the most, followed by liquids, and then solids. Solids, liquids, and gases also contracted when cooled. Further, you observed that not all materials expand to the same degree. The substance that expands the most when heated will contract the most when cooled. You explained all these observations using the particle model of matter.

Turn to pages 6 and 7 of Assignment Booklet 3A and answer questions 3 and 4.

Lesson 2: The Particle Theory and Changes of State

Imagine it's a hot, summer day and you are lounging on a beach. You notice that you are getting quite hot, so it is time for a dip. You gingerly place your toe into the water and, to your relief, find the water is quite warm. You plunge into the water and after five minutes decide it is time to return to your blanket and enjoy the Sun. You walk out of the water and without drying yourself off you lie back to enjoy the warmth of the Sun. However, now you find yourself shivering from the cold. The Sun is still out, the outside temperature is the same as when you went into the water, but now you are uncomfortably cold.

Why do you feel cold on a hot, summer day when there is moisture on your body? Why does sweating when playing a tough game of basketball actually cool you down? Why do Florida orange farmers spray their crops with water when the temperature gets close to freezing?

These questions and more will be answered as you work your way through this lesson.

Thermal Energy and Temperature Change

On a hot, sunny day at the beach, you may notice that the water stays cooler than the sand. Both substances absorb the heat from the Sun. Yet, the temperature of the sand increases much more than the temperature of the water. It seems the solar heat affects the sand more. The sand changes in temperature the most.

capacity: the ability to hold something

Because the sand goes up in temperature so much, you may think that the sand fills up with heat faster than water. It is as if sand cannot hold heat as well as water. The sand has a lower **capacity** for thermal energy. The high temperature of the sand gives the impression it is bursting at the seams with heat.

The **specific heat capacity** of a substance is based on the amount of thermal energy needed to cause a change in temperature of 1°C.

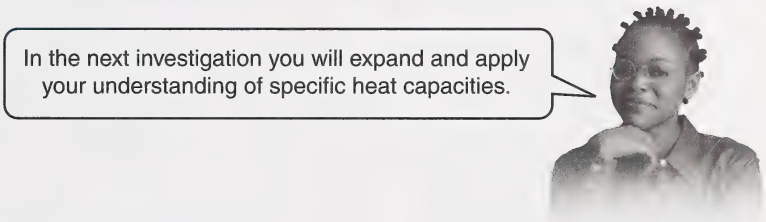
specific heat capacity: the amount of heat energy that must be gained or lost for 1 kg of a substance to change temperature by 1°C

Turn to page 218 of the textbook. Read the first few paragraphs of "Topic 5: The Particle Model and Changes of State." You will find out more about specific heat capacity and the related term **heat capacity**.

1. Define the terms *heat capacity* and *specific heat capacity*.

2. Based on the reading, which substance—sand or water—has a higher specific heat capacity? Explain.

Compare your responses with those in the Appendix, page 105.



Investigation 3-E Hot Stuff!

Read the entire investigation on page 219 of the textbook.

3. Perform the investigation, and answer the following.

   a. questions 1 to 4 of "Part 1: Rate of Temperature Change"

   b. questions 5, 6, and 7 of "Part 2: Size of Temperature Change"

Check your responses with your teacher or home instructor.

end of investigation

Changing State

On Denzil's birthday, he had a cake decorated with candles. As the candles burned, he saw the wax of the candle melt from the heat of the flame. Wax dripped down the side of each candle and solidified on the way down. The candle wax changed states.

Turn to pages 220 and 221 of the textbook. Read "Changes of State" and "Melting and Boiling Points" for more information on change of state.

4. Copy and complete the following table.

Relating Heat to State Changes			
Change of State	**Thermal Energy Change Required (added or removed)**	**Initial State (solid, liquid, or gas)**	**Final State (solid, liquid, or gas)**
melting			
freezing			
condensation			
evaporation			
sublimation (solid to gas)			
sublimation (gas to solid)			

5. Determine the phase change (process) that occurs when

   a. water vapour in the air touches a cold object and forms water drops

   b. solid carbon dioxide (dry ice) turns directly into a gas

   c. solid metal is heated so hot it begins to flow

6. "Melting and freezing points are the same but different." Explain this statement.

7. a. List the substances in Table 3 (on page 221 of the textbook) that are solid (frozen) at room temperature (21°C).

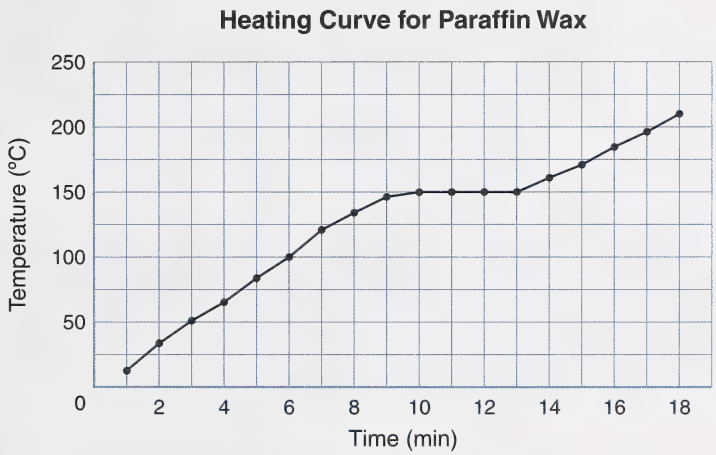
   b. List two substances in Table 3 that are liquid form at room temperature.

   c. List the substance in Table 3 that is in gaseous form at room temperature.

DID YOU KNOW?

Every day, 7.5 million tonnes of water evaporates from the Dead Sea, which is actually a large lake. The salt dissolved in the lake water stays behind. The Dead Sea has become six times as salty as Earth's oceans.

8. Mikaila heated a sample of wax for a period of time. She recorded her results and produced the following graph.



   a. At what temperature does paraffin wax melt?

   b. How did you identify that point as the melting point?

Compare your responses with those in the Appendix, pages 105 and 106.

Evaporative Cooling

Mr. Casey: Why do dogs pant?

Tara: Because they are hot.

Mr. Casey: Right! Panting exposes the wet surfaces of the tongue, mouth, and throat to the air. As air moves across these moist surfaces, water evaporates into the air, cooling down the dog.

The water particles absorb excess heat and take it out of the dog into the air. This is known as evaporative cooling. This process is very important for regulating body temperature.

Tara: Okay. I guess we're more civilized—we use evaporative cooling by sweating. It's not so noticeable.

So why do you feel cool on a hot day just after you come out of the water? The water on your skin evaporates. This requires the absorption of heat energy. Some of the heat comes from your body, giving you that cooling sensation. Read page 221 of the textbook for more evaporative cooling information.

9. Explain why sweating on the basketball court keeps your body temperature normal.

Compare your response with the one in the Appendix, page 106.

DID YOU KNOW?

There are over two million sweat glands on the surface of your body. The average person sweats out about half a litre of water each day—more if they are active on a hot day. Also, besides panting, dogs also sweat through their paws to stay cool.

Investigation 3-F The Plateau Problem

Turn to page 222 of the textbook. Read the introductory information, including "Question" and "Hypothesis."

10. Record your hypothesis by completing statements a. and b.

Compare your responses with those in the Appendix, page 106.

Now, read the entire procedure on pages 222 and 223 of the textbook. **Take special note of the safety precautions.**

Create your data table. Have your home instructor supervise as you perform the entire procedure. You can substitute a pot for the beaker when you are boiling the water and a glass when you are melting the ice. The finer your ice is crushed, the better your results will be. Remember, thermometers are very fragile. You cannot bump them or stir with them. Also, never heat a thermometer beyond the top of its range. This could happen if you allow the thermometer to rest on the bottom of the pan of boiling water. Melting and boiling can be done at different times.

11. Remember, heat was being added continually to both samples. The ice absorbed heat energy from the air and glass. The boiling water absorbed heat energy from the pot. Review the graphing skills guidelines on pages 476 and 477 of the textbook. Then answer these questions on page 223 of the textbook.

    a. questions 1, 2, 3, 4, and 6 of "Analyze"

    b. questions 9 and 10 of "Conclude and Apply"

12. You can tell when a substance is changing state because the heating curve _____.

Compare your responses with those in the Appendix, pages 106 to 109.

end of investigation

What Happens In-Between?

You know that 0°C is a special temperature for water. Water is solid below 0°C; it is a liquid above 0°C. But what happens to the particles at 0°C? The same question could be asked about water particles at 100°C. This is the special temperature where water changes from a liquid to a gas. How do particle speed and motion relate to temperature and state?

Turn to pages 224 and 225 of the textbook. Read "Why the Temperature Stays the Same."

13. Copy and complete the following summary statements.

    a. As temperature increases, the particles become _____ organized.

    b. As temperature decreases, the particles become _____ organized.

    c. During a change of state, the total energy of all the particles in the substance _____ and the average energy of the particles (temperature) _____. The energy that is absorbed or lost changes the _____ of the particles rather than the substance's temperature.

Compare your responses with those in the Appendix, page 109.

14. Turn to page 225 of the textbook. Answer questions 1 to 4 of "Topic 5 Review."

Check your responses with your teacher or home instructor.

Looking Back

In this lesson you applied the particle model to a number of real-life situations. You learned that there are three states of matter and six changes of state. You now know that energy can do one of two things when a substance is heated. It can increase the speed of the particles and, therefore, the temperature. Or it can rearrange the position of the particles, thereby causing a change of state.

Turn to pages 7 to 11 of Assignment Booklet 3A and answer questions 5 to 10.

Lesson 3: Transferring Energy

It's a chilly Alberta night to be outside riding snowmobiles. It has been fun, but now you are going back to the roaring campfire! You are sitting in front of it—warm on one side and cold on the other. Why aren't you warm all the way around your body?

Well, you have already dealt with the transfer of thermal energy! You know that if you were to touch one of the glowing embers, the sudden transfer of a large amount of heat would burn you. You know that when roasting marshmallows, holding them above the embers browns them much faster than holding them off to the side. You know that to warm your back, you are going to have to turn around. And, the closer you get to the fire, the faster you will warm up. But still, a question remains: why is it warm on one side and cold on the other?

In this lesson you will look at thermal energy transfer. The particle model of matter will be used for this. You will also use a new model—a model that does not even have particles.

Three Methods of Energy Transfer

Heat has been talked about a lot. It is finally time to define the term *heat*. Heat is, simply, energy that moves from a warmer substance to a cooler substance. Heat can transfer in three different ways:

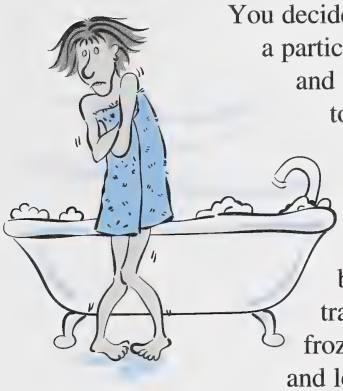
(1) **conduction** (by touch)
(2) **convection** (carried upward by particles)
(3) **radiation** (as an energy wave)

You know from experience that thermal energy always moves from a hotter substance to a cooler substance. Perhaps the following examples will be somewhat familiar to you.

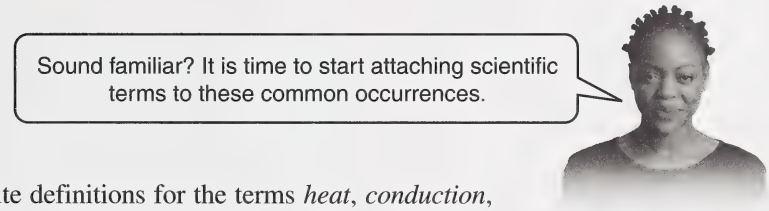
Example 1

You decide to run a hot bath for yourself. You need to relax after a particularly long day. You set the tap at the right position and add some bubble bath. A few minutes later, you return to ease yourself into the tub. The temperature of the bath is 43°C. Your body temperature is 37°C. Since the water is warmer than your body, thermal energy transfers from the bath water to you. Now you can start to relax.

Example 2



You decide to run a hot bath for yourself. You need to relax after a particularly long day. You set the tap at the right position and add some bubble bath. A few minutes later, you return to ease yourself into the tub. Unfortunately, your little brother just had a shower and two full loads of laundry were just done. Needless to say, the hot water tank was drained. The temperature of the bath is 28°C. Your body temperature is 37°C. Since your body is warmer than the water, thermal energy transfers from your body to the bath water. You feel frozen. A moment later you jump out of the tub, shivering and looking for a towel.



1. Write definitions for the terms *heat*, *conduction*, *convection*, and *radiation*.

2. Predict the primary (main) form of heat transfer that takes place in the following.

   a. roasting marshmallows over a fire

   b. sitting a few metres from the fire and only the front of your body is warmed

   c. climbing into a warm (or cold) tub of bath water

Compare your responses with those in the Appendix, page 109.

Radiation

What do light bulbs, toasters, and electric stoves have in common? Actually, several things! They are all appliances; they all convert (change) electrical energy into thermal energy; and they all produce light energy. In each case, the light energy is released as **radiant energy** or **electromagnetic radiation (EMR)**.

Turn to page 226 of the textbook. Read the first paragraph of "Topic 6: Transferring Energy." Then read "Radiation Transfers Energy." These readings introduce this method of energy transfer.

3. Define *radiant energy* (electromagnetic radiation).

4. List three characteristics of all forms of radiant energy.

5. Does radiant energy transfer require particles to hold/carry the energy?

Compare your responses with those in the Appendix, page 109.

In the sunshine, surfaces can become very hot. Have you ever touched the surface of a black car after it has been sitting in the sunshine for a few hours? Have you ever wondered why some windshield sunblocks—along with some tents and outdoor equipment—are silver in colour?

How do different surfaces affect radiant energy transfer? You will find out in the next activity.

Find Out Activity Absorb That Energy

Read through the entire activity on page 227 of the textbook.

You may find it easier to create paper and aluminum foil envelopes. Just slip the thermometer into them one at a time. Shine the bulb down on each envelope for the needed time. Remember to control your variables as closely as possible. Try to keep the texture, thickness, and area of paper the same. You should only be changing the colour or shininess.

You can change the procedure a bit so that it will work for you. You should create your data table as your first step. You can model it after the one that follows.
Note: The bulb gives off both radiant light and heat. Light energy absorbed by your surfaces will be converted (changed) into heat energy. The thermometer will indicate the result of absorbing both types of energy.

Absorption of Radiant Energy

Time (min)	Temperature (°C)	
	Light	Dark
0		
5		
10		
15		

Note: You could use the term "Shiny" instead of "Light" and "Dull" instead of "Dark."

6. Record your measurements in your data table. Draw a line graph to illustrate your results.

7. Answer questions 1, 3, and 4 of "What Did You Find Out?" Modify them as necessary to suit your situation.

Check your responses with your teacher or home instructor.

You now get to apply what you discovered in the previous activity.

Investigation 3-G Comparing Surfaces

Read the entire investigation on page 228 of the textbook. Then do the activity.

8. Complete the investigation by answering the following.

   a. questions 1 and 2 of "Procedure"

   b. question 3 of "Analyze"

Compare your responses with those in the Appendix, page 110.

end of investigation

Conduction

Mr. Casey: Appliances again! What do these three appliances have in common?

Austin: They convert electrical energy into thermal energy, too.

Mr. Casey: Yes. These appliances transfer heat by **conduction** to their target—a dress shirt, coffee pot, and popcorn kernels. Conduction is a method of heat transfer that requires contact. The particles of the substances in contact do bump into each other to transfer energy.

Turn to page 229 of the textbook. Read "Conducting Energy Through Solids." Study the figures carefully to get a visual image of the process of conduction.

9. Define the term *heat insulator*.

10. Explain why thermal conduction is like a chain reaction.

Compare your responses with those in the Appendix, page 110.

Find Out Activity The Super Stirrer

Now it's time to test your knowledge of conductors and insulators. Read the activity on page 229 of the textbook.

Make sure you work under the direct supervision of your home instructor. The hot water needs to be close to boiling for this activity to be successful. **Be careful not to burn yourself!**

11. Perform the entire activity. Then answer questions 1 and 2 of "What Did You Find Out?"

Compare your responses with those in the Appendix, pages 110 and 111.

Convection

Heat from a stove moves through a room by **convection currents**. Convective heat transfer can only occur in **fluids**. (Liquids and gases are both fluids.) The particles in fluids are free to move individually, carrying heat energy with them.

Turn to page 230 of the textbook. Read "Convection, Energy on the Move." Carefully study Figure 3.25. It shows the parts and sequence of a convection current. You should note that warmer air does not rise by itself. It is actually pushed up by the colder, **denser** air surrounding it.

12. Write definitions for the following terms:

    - *convection current*
    - *density*
    - *fluid*

13. Do solids transfer heat by convection? Why?

Compare your responses with those in the Appendix, page 111.

Going Further

Read "Find Out Activity: Displaced Drops" on page 231 of the textbook.

Perform the entire activity. A clear, colourless glass or jar can be used instead of a beaker. Handle the hot water with care under the direct supervision of your home instructor.

Once you have completed the activity, answer questions 1 to 4 of "What Did You Find Out?"

For more information on convection, view the segment "How Convection Works" on the *Science 7 Multimedia* CD.

Find Out Activity Displaced Thermal Energy

Get some personal experience with heat transfer. Under the direct supervision of your teacher or home instructor, light a candle; then do the following:

Situation 1: Hold a wire or a piece of metal cutlery in the flame. Keep it there until you feel the thermal energy from the flame being transferred to your hand. **Do not hold the object long enough to burn yourself.**

Situation 2: Slowly lower your hand above the flame. **Do not get low enough or hold your hand over the flame long enough to burn yourself.**

Situation 3: Hold your hands on either side of the flame. Bring them close enough to experience heat transfer. **Again, do not burn yourself.**

14. Identify the primary method of heat transfer in each of the three situations.

15. How did thermal energy reach your hand in the first situation?

16. What method(s) of heat transfer did you experience when you held your hand above the flame?

17. Which method is the primary method of heat transfer (transferred the most heat) in a fluid? (Remember, gases and liquids are both fluids.)

Compare your responses with those in the Appendix, page 111.

Controlling Heat Transfer

Fire! Beautiful or terrifying? Useful or destructive? Controlled or out of control? How do you view fire? Conduction, convection, and radiation are the three ways heat transfers from one substance or location to another. You and everyone else rely on these three methods to transfer energy from the Sun to the Earth, to circulate heat around the atmosphere and your home, and to cook your food. Heat transfer is very much a part of your everyday life. However, thermal energy can be very dangerous. The transfer of heat energy within buildings and appliances must be carefully controlled. You must be able to turn the heat source on and off and up and down. You have to keep thermal energy from leaking out from where you want it—say, from under your blankets. Effective and efficient energy transfer systems are vital in the modern world.

Turn to pages 231 to 233 of the textbook. Learn more about these vital systems by reading "Analyzing Energy Transfer Systems" and "Features of Energy Transfer Systems." Be sure to study the figures carefully.

18. Is heat a substance or something else?

Compare your response with the one in the Appendix, page 111.

There are five features that are common to energy transfer systems:

(1) **Energy Source:** This is the part of the system that supplies the energy.

(2) **Direction of Energy Transfer:** Heat energy always moves from the area or substance with the higher temperature to areas or substances with lower temperatures.

(3) **Energy Transformations (Conversions):** Energy is often changed from one form to another as it moves through the chain of events involved in an energy transfer system.

(4) **Waste Heat:** Any thermal energy that does not reach the target is transferred into the surroundings.

(5) **Control Systems:** These are devices or means to control the original heat source.

19. The following photograph is an example of a very simple heat transfer. Identify the following components: energy source, direction of energy transfer, an energy transformation, wasted heat, and a control system.

Compare your response with the one in the Appendix, page 112.

Going Further

Apply and expand your knowledge of energy transfer by building your own heat-transfer system. Get together with your teacher or home instructor and try "Investigation 3-H: Making a Transfer" on page 234 of the textbook.

Preventing Heat Transfer

Living in Canada, you are probably very familiar with insulation. Things like wool mitts, a warm jacket, and the itchy, pink stuff they put in the walls of houses all prevent heat transfer. For the most part, people are concerned about preventing heat from transferring out of a system. For example, the heat that is lost from your body or house on a cold day. However, heat transfer into a system can also be unwanted. For example, the less heat that transfers into your home on a hot day, the more comfortable you will be.

Insulation can be used to prevent all three types of heat transfer in one or both directions. Read "Unit 3: Ask an Expert" on pages 258 and 259 of the textbook. Then turn to page 235 of the textbook. Read "Find Out Activity: Keeping in the Warmth" up to the Procedure.

20. How is the heat energy in your home lost to the outside air?

21. What does the RSI value indicate?

22. Which of the listed materials is the best insulator? the best conductor?

23. What is the RSI value of 10 cm of fibreglass?

Compare your responses with those in the Appendix, page 112.

Investigation **The Big Meltdown**

Challenge—Protecting an Ice Cube

Ice cubes melt quite quickly on hot, summer days. Can you make one last five times longer than usual? Design and build an insulated structure that will protect an ice cube from melting.

Materials

- two or more ice cubes as close to the same size as possible
- a variety of structural and insulating materials

Specifications

A. Your goal is to design and build a structure that will greatly increase the time it takes to melt an ice cube.

B. You can only use everyday materials you can find around the house.

C. You can build and test as many insulating structures as you like.

D. If possible, have your friends, family, teacher, or home instructor take part in the activity. Brainstorm ideas about how to build the structure, like

- materials that make good insulators
- the thickness of the insulating material
- heat transfer methods—radiation, convection, and conduction

E. Sketch a labelled design proposal for each structure.

F. Plan a table to store your data in.

G. If your structure doesn't give good enough results, suggest changes to the design. Modify it accordingly, and test again.

Evaluate

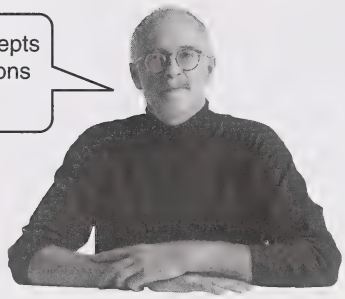
There is a lot of information in this module that can help you. Create a point-form summary of the ideas you used to design your structures.

24. How could you or did you improve your structure to repeat this experiment?

Compare your response with the one in the Appendix, page 112.

end of investigation

You have now completed the new concepts for this lesson. Do the following questions to review what you covered.



25. Turn to page 236 of the textbook. Answer questions 1 to 4 of "Topic 6 Review."

Check your responses with your teacher or home instructor.

Looking Back

After completing this lesson, you will know that it is mainly radiant energy that keeps you warm when you sit beside a campfire on a cool evening. Radiant energy travels as an energy wave. It travels in a straight line and is absorbed at the surface of your body. It does not reach the far surface of your body—usually your back. That's why you feel warm on one side and cold on the other.

You applied the particle model to the concept of heat transfer. You learned that there are three methods of heat transfer—conduction, convection, and radiation. You also learned that every heat transfer system shares five common features. In the end, you applied your knowledge. You designed and built structures meant to prevent energy transfer.

Section 2 Review

You have now completed the concepts for this lesson. To review what you covered, answer the following: Wrap-up: Topics 4–6" questions on page 237 of the textbook.

1. Answer question 1 of "Reviewing Key Terms."

2. Answer question 4 of "Understanding Key Concepts."

Check your responses with your teacher or home instructor.

Conclusion

In this section you applied your knowledge of the particle model and thermal energy to real-life situations. You found that solids, liquids, and gases all expand when heated and contract when cooled. You found that gases expand more than liquids, and liquids more than solids. You also found that different solids expand at different rates. This is also true of liquids and gases. You then observed matter changing states and learned that there are three states of matter. Matter moves continuously between these states. You explained these observations using the particle model. You demonstrated that energy is always being transferred from one area to another and from one form to another. You also discovered that there are three methods of heat transfer. You used the particle model in explaining heat transfer. Based on principles of heat transfer, you designed ways to conserve thermal energy.

When you are in a car going over a bridge, you will hear at least two sets of thumps. The first set is felt as you drive onto the bridge and the other set as you drive off the bridge. Maybe you have heard these thumps before, but didn't know what caused them. Well, now you know! These thumps come from the expansion gaps at each end of the bridge. So, the next time you hear those thumps, think of the bridge design. It has made the bridge safer by making allowances for the expansion and contraction.

Turn to pages 12 to 14 of Assignment Booklet 3A and answer questions 11 to 15.

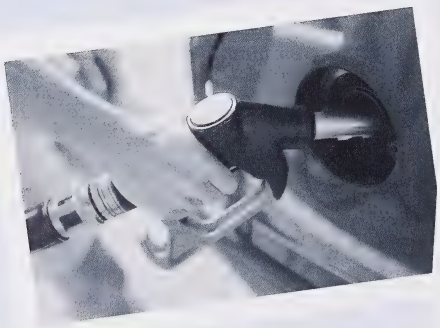
Section 3

Using Thermal Energy Effectively

There is an abundance of gasoline in Alberta. A gas station never seems to be far away. It's easy to get the gas needed to run your family car—or so it seems until you see the final dollar-and-cents figure. A tank of gas does not come cheap.

Imagine a car just running on sunshine. You would never need to go near a gas station again. Students at the University of Alberta have built such a car—a solar car. They are promoting environmental responsibility and alternative energy awareness. That is the intent of this section of this module. Having energy awareness may help you save some money too.

In this section you will deal with environmental issues related to the use of different thermal technologies. You will evaluate a variety of sources of thermal energy based on their environmental impact. You will also compare the energy consumption of different technologies used to provide thermal energy. Finally, you will consider ways to conserve energy in your home and community.



UNIVERSITY OF ALBERTA SOLAR VEHICLE PROJECT

Lesson 1: Sources of Thermal Energy

Have you ever been called indoors when a thunderstorm was approaching? If a bolt of lightning struck the ground near you, you would feel the huge amount of energy it contained. The air around the bolt is instantly heated to around 30 000°C. A single lightning bolt contains massive amounts of electrical energy. It could light a 100-watt light bulb for three months. The energy comes to you in several forms: electrical, sound, thermal, and light.

Why might you want to control the energy created by lightning? It would provide a huge, pollution-free, renewable source of energy. Modern society needs such an energy source. Perhaps you will find a new environmentally friendly energy source to power the world.

It's too bad energy could not be made from nothing. Then scientists would not have to try to tame lightning storms or think of other sources of energy. It is the Law of Conservation of Energy that gets in the way of getting energy for nothing.

> *Energy cannot be created or destroyed. It can only be transformed (converted) from one type to another or passed (transferred) from one object to another.*

In this lesson you will study sources of energy. You use these sources to heat your home, cook your food, and power the vehicles you rely on. You will also think about the impacts each of these energy sources has on the environment.

Energy Sources

Have you ever seen a geyser? Maybe you have seen Old Faithful, the most famous geyser in North America. Old Faithful is in Yellowstone National Park, Wyoming, United States. Old Faithful erupts roughly every 76 minutes. During each eruption, 14 000 L to 32 000 L of extremely hot water and steam are shot 30 m to 55 m into the air. Needless to say, Old Faithful spouts off a lot of geothermal energy.

Have you ever heard of **geothermal energy**? Think about what the word implies. *Geo* refers to "Earth" and *thermal* refers to "heat." When you put the two together, you have "Earth heat." That is exactly where the heat energy comes from. In some places, people have harnessed geothermal energy. Geothermal energy is just one of many sources of energy.

Turn to page 238 of the textbook. Read the introductory information of "Topic 7: Sources of Thermal Energy." Then read the first paragraph of "Find Out Activity: Energy Inputs for Energy Outputs." Focus your thoughts on energy conversion and a variety of direct and indirect sources of heat energy.

1. What process is used to break crude oil into usable parts?

2. Turn to page 238 of the textbook and answer questions 2 and 3 of "What Did You Find Out?"

Compare your responses with those in the Appendix, page 113.

Going Further

Start out simple! Think about the amount required to heat your home with something as simple as wood. Turn to page 238 of the textbook. Follow the directions in "Find Out Activity: Energy Inputs for Energy Outputs."

Electrical power lines are a common sight. People tend to take energy for granted, using it without thought. However, no energy source is free. There are always costs associated. It has to be found, collected, transported, and distributed.

Consider these costs during the readings in this lesson. These readings will be discussing many of the forms of energy people use.

Turn to pages 239 and 240 in the textbook. Read "Chemical Energy," "Electrical Energy," and "Mechanical Forces."

3. Write definitions for the following terms:

   - *energy*
   - *electrical energy*
   - *mechanical energy*

4. Examine the power lines in the preceding picture. Based on the picture, give a qualitative description of the current temperature in this area. Explain your answer.

5. Use the particle model to explain why a nail feels warm after it has been hit by a hammer.

Compare your responses with those in the Appendix, page 113.

Now, you will learn about some energy sources that are slightly less mainstream. Turn to pages 240 to 243 in the textbook. Read "Geothermal Energy," "Solar Energy," and "Wind Energy."

6. Geothermal energy can be an excellent source of thermal energy because it has a minimal impact on the environment. However, there are costs. List some of the financial and energy inputs required to harness geothermal energy.

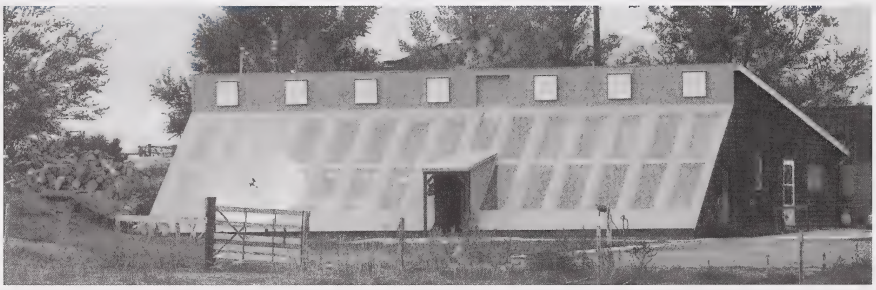
7. Southern Alberta is home to a number of wind-powered plants. Why do you think this technology is most prominent in the southern part of Alberta?

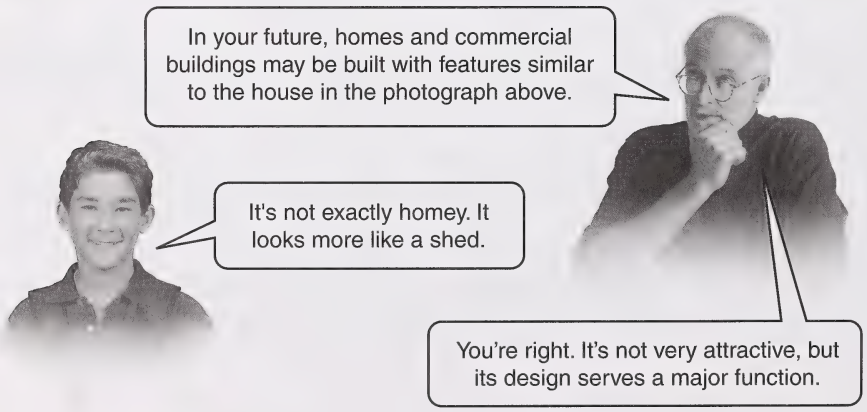
8. Write definitions for the following terms:

- *geothermal energy*
- *solar energy*
- *wind energy*
- *passive solar heating*
- *active solar heating*
- *solar collectors*

Compare your responses with those in the Appendix, pages 113 and 114.

Solar Heating




In your future, homes and commercial buildings may be built with features similar to the house in the photograph above.
It's not exactly homey. It looks more like a shed.
You're right. It's not very attractive, but its design serves a major function.

9. What is the difference between active and passive solar heating?

10. Solar energy is quite reliable and clean. Why do only a few houses in Alberta make use of this heat technology?

Compare your responses with those in the Appendix, page 114.

DID YOU KNOW?

Solar energy was used to power toys in 1615.

Fossil Fuels and the Environment

Coal is a fossil fuel. Albertans rely heavily on this non-renewable energy resource. It is burned to produce electrical energy. You have already seen two problems with burning fossil fuels (page 52 of the textbook). Burning releases carbon dioxide, sulfur, and nitrogen stored in the fuel. Sulfur and nitrogen combine with water in the atmosphere to produce acid rain. Carbon dioxide is a **greenhouse gas**.

Turn to pages 245 through 247 in the textbook. Find out more as you read "Fossil Fuels," "Fossil Fuels: Two Problems," and "Global Warming." Then read "Stretch Your Mind" on page 236 of the textbook.

11. Write definitions for the following terms:

- *non-renewable resource*
- *renewable resource*
- *greenhouse gases*
- *energy resource*
- *fossil fuel*

12. How much longer are the world's supplies of non-renewable fossil fuels expected to last with the current technologies and rates of consumption?

13. Why is carbon dioxide a greenhouse gas?

14. Read the "Did You Know?" on page 247 of the textbook. How much have average global temperatures risen in Antarctica in the last few decades?

15. Classify the type of energy represented in each of the following pictures. Some can be classified in more than one way. The following images represent sources of energy.

A.

B.

C.

D.

Match the pictures with the following energy sources.

_____ chemical
_____ fossil fuel
_____ solar
_____ wind

Compare your responses with those in the Appendix, pages 114 and 115.

DID YOU KNOW?

A jumbo jet can burn more than 18 000 L of fuel just during takeoff.

How would you like to live in a home like this geodesic greenhouse? What do you think it would be like on a hot day? on a cold day? It is like climbing into a Sun-warmed car on a cold day.

The next investigation allows you to actually examine a greenhouse in a scientific, quantitative way.

Investigation 3-J Simulating the Greenhouse Effect

Turn to page 246 of the textbook. Read the entire investigation and then make your prediction. Do you have access to the equipment suggested? If not, an alternate equipment list and procedure are provided.

Materials

- 2 identical glass jars
- 1 L (4 cups) of cold water
- 10 ice cubes
- clear, glass lid (or clear plastic bag)
- thermometer

Procedure

step 1: Pour 1 L of cold water into each of the two jars.

step 2: Add 5 ice cubes to each jar.

step 3: Tightly cover one jar with the clear lid (or plastic bag). This is the greenhouse jar.

step 4: Leave both jars in the sunshine for one hour. Then measure and record the temperature of the water in each jar.

16. Answer the following on page 246 of the textbook.

    a. questions 2 and 3 of "Analyze"

    b. question 4 of "Conclude and Apply"

Check your responses with your teacher or home instructor.

end of investigation

Using Waste Productively

Just think of the amount of energy it takes to run one city for one night! Think about a really cold, dark winter night. Wouldn't it be great if some of that energy came from the garbage that people create? Or, perhaps even use the waste heat released by industry? This is, in fact, being done in some areas on a small scale.

Turn to page 247 of the textbook. Review the thermal applications of cogeneration by rereading "Cogeneration."

17. Define the term *thermal pollution*.

Compare your response with the one in the Appendix, page 115.

DID YOU KNOW?

A car's engine converts the energy in gasoline into other forms. About three-quarters becomes waste. Only one-quarter goes to turning the wheels.

18. Turn to page 247 of the textbook. Answer questions 4 and 5 of "Topic 7 Review."

Check your responses with your teacher or home instructor.

Looking Back

People haven't yet harnessed lightning, but harvesting the wind is common. In the breezy southern areas of Alberta, wind generators are becoming quite common. They are contributing more and more to the provincial electrical supply. Energy can be transferred and transformed from many sources and locations. Now you can light and heat your home, cook your food, or move from place to place with it. Each of these changes follows the Law of Conservation of Energy. You do not get energy for nothing.

In this lesson you were introduced to a variety of energy sources. You were told that fossil fuels will run out. You saw that continued use of fossil fuels at the current rates will hurt the environment. You also found out that there are a number of alternate energy sources. Often, they are not widely used due to higher costs and their distance from where the energy is needed. You also saw that no energy source comes without a cost. Cost, in terms of dollars and cents, is a major factor in choosing an energy source. People will start using clean, alternate energy sources when the price is right.

Turn to pages 1 to 3 of Assignment Booklet 3B and answer questions 1 to 8.

Lesson 2: Conserving Fossil Fuels

Do you remember studying ecological footprints in Module 1? You saw that human wants and needs impact the environment to some degree. Impacts can be negative, positive, small, or large. With knowledge and awareness comes choice. Your knowledge and awareness is growing on a daily basis and so are your choices.

How much energy do you, your family, your community, and your province use each day? The amount is very difficult to imagine, but you know it must be huge. There is much concern about the amount of energy being used. Both because it has a major effect on the environment and because the fossil-fuel supply is running out. Humans have been burning fossil fuels in a major way for almost 100 years! What is likely to happen in the next 100 years?

Is it important to think about how much energy you use? Is it important to try to reduce your use of fossil fuels to conserve them for as long as possible? What can you do to use less energy than you do now? These are questions you will consider in this lesson.

Why Conserve?

Think about it! Why would you want to conserve energy? Exactly what would you get out of being frugal with energy? Are you concerned about a polluted environment? about personal health problems related to air quality? about wasting non-renewable resources? about higher financial costs to your family?

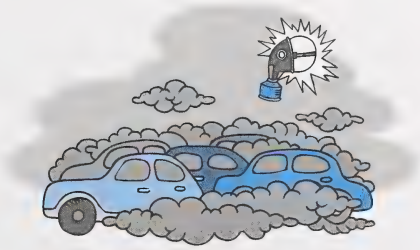
Why you should use energy carefully will be the topic of this lesson. Most reasons for conserving energy sources revolve around the following:

- **cost to the consumer:** The less you use, the less you pay. Financial costs will continue to increase over time.
- **depleting resources:** The less you use, the longer the fossil fuels will last.
- **environmental concerns:** The less you use, the better it is for the environment.
- **personal health:** The less you use, the healthier you are likely to remain. Many of the pollutants related to energy use affect human health.

As you work through this lesson, keep these personal conservation reasons in mind. See if you can determine the benefit of some of the energy-conserving methods suggested.

Turn to page 248 of the textbook. Start by reading the introductory paragraphs of "Topic 8: Conserving Our Fossil Fuel Resources."

1. Today, fine particles of rubber are created as automobile tires wear away. These particles blanket cities and enter people's lungs, causing respiratory problems. Exhaust billows from vehicles, releasing a variety of pollutants into the air. How does this compare with the days of the horse and carriage and people's vision of the future with the automobile?



Compare your response with the one in the Appendix, page 115.

Could something as simple as changing the way you get clean improve your ecological footprint? How many tiny, individual drops of water does it take to fill that bathtub? One by one, little by little, it adds up to a lot. The next investigation gives you a chance to add your drops—knowledge that can help you choose wisely.

Investigation 3-K You Choose!

Turn to page 249 of the textbook. Read the first paragraph of the investigation. Look at the schematic diagram. Then read through and complete the steps of the procedure. If you are working alone, you may omit step 2.

2. Answer the following on page 249 of the textbook.

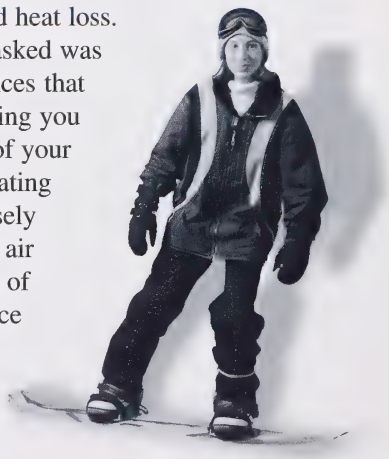
   a. questions 2, 4, and 5 of "Analyze"

   b. questions 1, 2, and 3 of "Extension"

Check your responses with your teacher or home instructor.

end of investigation

You know how to insulate yourself to prevent rapid heat loss. In Investigation 3-K, one of the options you were asked was about insulation. Remember, insulators are substances that **do not** conduct heat well. They are useful for keeping you warm in the winter. They help keep heat in or out of your house. Do you recall that down and synthetic insulating fibres contain multitudes of tiny air pockets? Coarsely ground, fluffed newspaper also contains many tiny air pockets. It is commonly used as insulation in attics of houses. (It has to be treated with chemicals to reduce the fire hazard.)



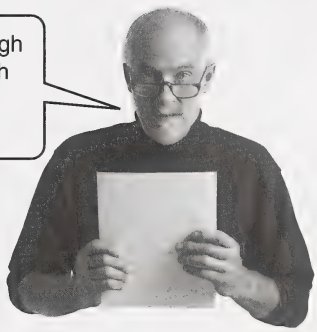
In the next investigation you get quantitative. You will be studying the insulating value of newspaper.

Investigation 3-L Keep It Warm

Turn to page 250 of the textbook. Read the introductory statements and the question of the investigation. Now, record your hypothesis in your notebook. Finally, read steps 1 to 5 of the procedure, and examine the pictures.

You will test 0, 3, and 6 half-sheets of newspaper. Prepare a data table similar to the one on page 251. (You can try to save some time by doing all three cans at once. Once you've started the first can, start the second, then the third. It will keep you hopping to get all the temperatures read on time.)

The water and heat source will be hot enough to burn you. Repeat the procedure for each sample under the direct supervision of your teacher or home instructor.



3. Answer the following on page 251 of the textbook.

   a. questions 3 and 4 of "Analyze"

   b. questions 5 and 6 of "Conclude and Apply"

Compare your responses with those in the Appendix, pages 115 and 116.

end of investigation

Turn to pages 3 and 4 of Assignment Booklet 3B and answer questions 9, 10, and 11.

Going Further

Someday, your life could depend on the insulating value of your clothing or shelter. Use the library or the Internet to research the protection offered by cold-weather materials. Follow the guidelines in question 10 of "Extension" on page 251 of the textbook.

Keeping It Hot or Cold

What good would it be if a hot tub wasn't hot or if a refrigerator wasn't cold? They both need a way to keep their temperatures just right.

Turn to page 252 of the textbook. Read "It's Hot in Here!" and "It's Cold in Here!" Find out more about these hot and cold systems.

4. An air conditioner moves heat in a similar manner to a refrigerator. What part of the evaporation-condensation cycle happens indoors? Why?

5. What information is found on an EnerGuide label?

Compare your responses with those in the Appendix, page 116.

Cooking food costs money and energy. How do the costs compare? Think about it as you do this awareness-promoting investigation.

Investigation 3-M How Much Energy?

Turn to page 253 of the textbook. Read through the entire investigation. Complete steps 1 to 4 of the procedure.

6. Answer questions 1, 2, and 3 of "Analyze" on page 253.

Compare your responses with those in the Appendix, page 116.

end of investigation

Thermal Danger

Have you ever had a steam burn from a boiling kettle? This type of burn is certainly not uncommon. They, like all burns, can be very painful and life-threatening. Proper use and care of energy transfer systems is important to personal and community safety.

Turn to pages 254 and 255 of the textbook. Read "Danger: Thermal Energy" and the first paragraph of "Find Out Activity: Store It Safely."

7. Why is it dangerous to store paints, solvents, and fuels in the basement?

8. If the oven mitt is a poor conductor, then it is also a good _____.

Compare your responses with those in the Appendix, page 116.

The By-Products of Combustion (Burning)

Carbon monoxide—the silent killer—has caused many deaths in houses and in stranded cars. Carbon monoxide is one of the chemicals released by burning fossil fuels. Turn to page 256 in the textbook. Read "By-Products of Thermal Energy Use." You will learn more about by-products of burning fossil fuels.

9. Sulfur dioxide combines with water in the atmosphere to form sulfuric acid. It then falls as acid precipitation (rain, snow, or fog). Why would sulfur dioxide be irritating to the eyes, nose, and throat?

10. What are two symptoms of carbon monoxide poisoning?

Compare your responses with those in the Appendix, page 116.

DID YOU KNOW?

The average car produces 1000 kg of harmful gases each year.

You have now completed the new concepts for this lesson. Do the following questions to review what you covered.

11. Turn to page 256 of the textbook. Answer questions 1 to 4 of "Topic 8 Review."

Check your responses with your teacher or home instructor.

Turn to pages 4 and 5 of Assignment Booklet 3B and answer questions 12 to 14.

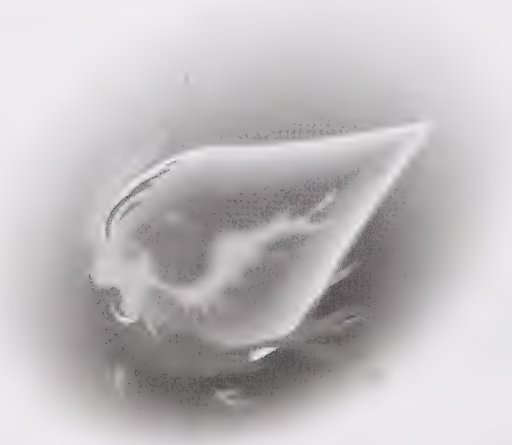
Energy: A Hot Topic

Note: An issue is a circumstance that arises that involves different points of view. It will have more than one possible solution. The best solution cannot be agreed upon.

The use of energy can be a controversial topic. The amount of energy people use and the pollution it produces are often "hot" issues in the news.

The debate over the Kyoto Protocol was one such "hot" topic. The Kyoto Protocol calls on industrialized nations (including Canada) to reduce greenhouse gas emissions.

Now, it's your turn. Consider the three real-life energy issues given. Read through the passages presenting the issues and answer the questions.



Issue 1: Calgary's New Power Plant

How do ordinary people get a say on issues? Sometimes it is through public hearings in front of government boards. One such board is the Alberta Energy and Utilities Board. This board has to approve the building of new electrical power plants. Often, boards will approve projects, but add conditions that have to be met. The project is said to be conditionally approved.

On December 11, 2001, a $500 million natural gas-fired power plant was conditionally approved. It is to be located 1.6 km east of Calgary's city limits. The plant will produce electricity to service over 500 000 homes.

To see the news release made by the Alberta Energy and Utilities Board, visit the following Internet site.

http://www.eub.gov.ab.ca/BBS/new/newsrel/2001/nr2001-38.htm

12. The Alberta Energy and Utilities Board is appointed by the provincial government.

    a. There are always safety concerns with new plants. What concerns would have been considered before approving the plant?

    b. Why do you think the plant is so close to the city limits?

13. What do you think might happen to the price of electricity if this plant is built? Explain your answer.

14. "I am fully disappointed with the decision to build the power plant," said a local resident. Why do you think this decision is making some local residents unhappy?

15. Local resident Mrs. Olinski was pleased. "I am very happy about the decision to build the power plant nearby." Why do you think this resident would be happy with the decision? Give three reasons you can think of.

Check your responses with your teacher or home instructor.

Issue 2: Sports Utility Vehicles: Yes or No?

Sport utility vehicles (SUVs) are very popular. An SUV is a large multi-purpose vehicle. It can be used as a family car. It can double as an off-road, four-wheel-drive truck.

The table that follows gives data on fuel use of a few vehicles. The data is for the year 1994. It was found on a United States Federal Government website, so the fuel use is recorded in gallons.

Average Yearly Fuel Consumption of Vehicles in 1994

Vehicle	Consumption (gal)	Consumption (L)
Passenger	514	1946
Pickup	682	2582
SUV	778	2946
Minivan	682	2582

The popularity of SUVs has become an issue in some areas of the country. The table shows that they use more energy than other family vehicles. People are willing to pay for the extra fuel. They want to drive a large, comfortable, multi-purpose vehicle.

Now, imagine you are a Member of Parliament (MP). A bill to ban SUVs (due to an excess use of fossil fuel) by the year 2005 is proposed. Answer the following questions about this issue.

16. The data in the table given was taken from one Internet site.

    a. How do you know if the information is reliable?

    b. How might a person become better informed about this issue?

17. Describe the perspective (viewpoint) the following people might bring to this issue.

    a. a person who likes to camp in off-road areas

    b. an owner of the local gas station

    c. a person concerned with the environment

    d. a salesperson at a dealership

18. One SUV owner stated that he had the right to drive an SUV because he could afford to pay for the gas. How do you feel about this point of view?

19. What position would you take on this bill?

20. What actions could citizens who do not agree with the bill take?

Check your responses with your teacher or home instructor.

Issue 3: Cycling in the City

A politician in a big city wants to build new bike paths. The idea also includes reparing paths already in place. The cost would be $50 million of tax money over the next three years. These bike paths would run between suburbs and to the downtown area.

21. Why would the city want to promote and make it easier to ride bikes?

22. State the perspective that the following people might bring to this issue.

    a. a bicycle owner

    b. a taxpayer who does not ride a bicycle

    c. a construction company bidding for the contract

    d. a salesperson at a car dealership

Check your responses with your teacher or home instructor.

Looking Back

In this lesson you were introduced to the concept of conservation of energy resources. You were asked to make choices with regards to energy consumption. You tried to balance cost, pollution levels, and making resources last. You were provided with a number of methods to reach those goals. It's one thing to know that you need to be conserving energy. It is another to change your life to reduce the amount of energy you use.

Section 3 Review

Turn to page 257 in your textbook. The following "Wrap-up: Topic 7–8" questions will help you review and apply the work you did in this section.

1. Answer question 1 of "Reviewing Key Terms."

2. Answer questions 2 to 10 of "Understanding Key Concepts."

Check your responses with your teacher or home instructor.

Conclusion

This section was about using resources for thermal energy. It talked about using these resources without hurting the environment and without wasting the resources. Fossil fuels are limited. Eventually, they will be used up. You evaluated different sources of thermal energy (like coal, gas, oil, solar, and wind). You saw the environmental impacts of their use. You compared the input energy needed for various thermal technologies and considered the safety of these technologies. You identified unintended consequences of energy use, such as global warming and pollution. You discovered ways you can reduce the use of energy resources.

You looked at issues related to thermal energy and fossil fuels. You found that there are many ways to look at things. You saw that it is important to respect other people's perspectives. This often involves compromising when coming to decisions.

Maybe someday you will operate a car that runs strictly on solar power. Maybe there'll be an option to "top up" stored energy with electricity. You won't have a gas tank opening but a place to plug in an extension cord. With your high-tech car you will be able to avoid the high prices at the pumps. You will also be getting around in a very environmentally friendly way.

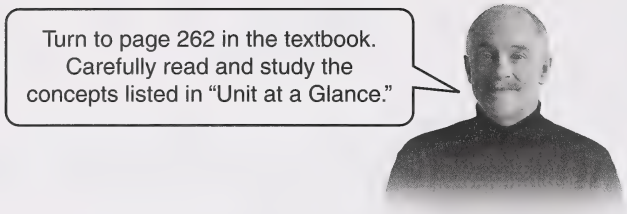
Turn to page 6 of Assignment Booklet 3B and answer question 15.

Module Summary

In this module you were shown how people meet their energy needs. They produce, transfer, and transform heat energy. In finding out about the nature of heat, you looked into sources and uses of heat energy. You explored different technologies, investigated the scientific principles involved, and considered questions about the nature of heat. You used the particle model of matter. It helped show how heat and temperature are related. It also helped explain your observations of expansion and contraction and changes of state. You also thought about the long-term ability to meet thermal energy needs from fossil fuels and renewable sources.

Think back again to these events: roasting a marshmallow over an open fire, leaving school on a cold winter day without a coat, and getting your tongue stuck to a very cold ice pop. What made these events memorable? It was the central role of temperature and heat. Now that you have completed this module, you can explain

- why a marshmallow roasts above an open flame
- why you shiver when you are cold
- why your tongue can stick to a cold ice pop
- many other events that involve temperature and heat



Answer the following "Unit 3 Review" questions on pages 262 to 265 of the textbook.

1. question 1 of "Understanding Key Concepts"
2. questions 3, 4, and 5 of "Developing Key Skills"
3. questions 7, 8, 11, 13, and 14 of "Problem Solving/Applying"
4. questions 19, 20, 21, and 23 of "Critical Thinking"

Check your responses with your teacher or home instructor.

Turn to pages 6 to 12 of Assignment Booklet 3B and complete the Final Module Assignment.

Appendix

Glossary

Suggested Answers

Image Credits

Glossary

active solar heating: a type of solar heating in which mechanical means are used to store, collect, and distribute solar energy in buildings

boiling: the process of rapid evaporation characterized by bubbling

change of state: (phase change) the process whereby a substance changes from one state to another as thermal energy is added or removed

cogeneration: the process of burning previously wasted materials or capturing waste thermal energy to provide heat for some useful purpose

compress: to squeeze a substance so the particles of the substance move closer together

conduction: heat transfer from particle to particle by touch

This is the primary method of heat transfer in solids.

contraction: the process in which a substance decreases in volume (as thermal energy is released)

convection: a method of heat transfer in which lighter, warmer, less-dense fluids (gas or liquid) are pushed upward by heavier, colder, denser fluids

This is the primary method of heat transfer in fluids. Particles carry the heat. This cannot occur in solids because the particles are fixed in place.

convection current: the roughly circular pattern that results from the heating and cooling of particles in a fluid

Lighter, warmer, less-dense fluids are pushed upward by heavier, cooler, denser fluids. As they move, they lose heat to the environment, become denser, and begin to sink. This creates a circular particle/energy flow.

density: how closely packed or thick a substance is; the amount of matter (number of particles) packed into a particular volume

The density of 1 million particles in a 5-cm^3 space is less than the density of 10 million particles in a 5-cm^3 space.

electrical energy: energy due to the flow of electricity

energy: the ability to do work, move, or cause a chemical or physical change

energy resource: an object or material from which energy is transferred

evaporate: to turn a substance from a liquid state to a gas state due to the addition of thermal energy

expansion: the process in which a substance increases in volume (as thermal energy is absorbed)

fluid: a liquid or a gas

The particles of a fluid are free to move (flow) individually. The particles of a solid are bonded (or fixed) in place. They are not free to move individually.

fossil fuel: any fuel made up of the remains of organisms that died millions of years ago and were buried deep underground

Natural gas, oil, and coal are examples of fossil fuels.

freeze: to turn a substance from a liquid state to a solid state as thermal energy is removed

geothermal energy: thermal energy obtained from the Earth's interior

global warming: an increase in the temperature of Earth's atmosphere due primarily to the increase in levels of greenhouse gases

greenhouse gases: gases that trap thermal energy within the atmosphere

heat: thermal energy transferred from a warmer substance to a cooler substance

heat capacity: the amount of thermal energy that must be absorbed or lost to change the temperature of a substance or object by 1°C

heat insulator: a material that conducts heat poorly

joule: the standard SI unit of energy

kinetic energy: the energy of motion

Any moving object or particle has kinetic energy.

matter: anything that takes up space and has mass

mechanical energy: energy due to the motion or the position of an object

melt: to turn a substance from a solid state to a liquid state by adding thermal energy

non-renewable resource: an energy resource that is not naturally replaced for millions of years

particle model of matter: the scientific model of matter in which matter is depicted as consisting of tiny particles

passive solar heating: solar heating that relies on architectural design rather than mechanical means to collect solar energy

radiant energy: (electromagnetic radiation) energy that transfers in the form of a wave

Unlike convective and conductive heat transfer, the energy is not carried by particles.

radiation: a method of heat transfer that requires no particles

Radiant energy transfers in the form of waves. For example, radiant heat and light energy travels from the Sun to Earth through the vacuum of space.

refrigerant: a liquid used in refrigeration

Refrigerants evaporate easily at low temperatures. Refrigerants move heat from one place to another through the process of evaporation and condensation.

renewable resource: an energy resource that can be recycled or replaced by natural processes in less than a hundred years

resource: an available supply of certain materials

responder: an organism or mechanism that receives or uses a signal in some way

scale: a series of marks or points at certain intervals used to measure distances

sensor: a device or material that is affected by changes in some feature of the environment, such as temperature

signal: a physical quantity, such as electric current, used to transmit information

solar collectors: the parts of an active solar heating system that are exposed to sunlight for the absorption of thermal energy

solar energy: energy obtained from the Sun

specific heat capacity: the amount of thermal energy that must be absorbed or lost to change the temperature of 1 kg of a substance 1°C

sublimate: to turn a substance from gas to solid or solid to gas as thermal energy is removed or added without the substance going through the liquid state

temperature: the average energy level of the particles in a substance

thermal conductor: a substance that transfers heat energy quickly

thermal (heat) energy: the total kinetic energy of all the particles in a substance

thermal insulator: a substance that transfers heat energy very slowly

thermal pollution: the release of waste thermal energy, causing unintended heating of the environment

Often, industrial discharge of heated water into a river, lake, or other body of water causes a rise in temperature that endangers aquatic life.

thermometer: a mechanical or electrical device used for measuring temperature

vapour: gas

volume: the three-dimensional size of an object or substance; the amount of space it occupies

wind energy: energy obtained from moving air

Suggested Answers

The answers in this Appendix are an important part of this Science course. Read them carefully when checking your work. They provide additional information, examples, and clarification. They also give you a quick way to see if your answer is right. It is a good idea to copy the things you learn into your notebook. What you learn from the suggested answers is often used later in the module or course. Refer to them as needed.

Section 1: Lesson 1

1. Check your responses with your teacher or home instructor.

2. Answers will vary. A sample answer is given.

Considering Change		
Task	**How Task Was Accomplished 100 Years Ago**	**How Task Is Accomplished Today**
washing clothes	Clothes were placed in a large basin and left to soak in soap and water. Then each item was rubbed against a washboard or stone to get the dirt out.	Clothes are washed in a washing machine. The washing machine is first turned on; soap is added; then the clothes are placed inside the washer.
drying clothes	Clothes were hung on a line strung between two trees or poles (known as a clothesline) and left to air-dry.	Usually, an automatic clothes dryer is used. However, due to economic, environmental, or personal reasons, some people still use a clothesline.
warming leftovers	Leftovers were reheated in a pot on top of a wood stove. This process may have taken 10 to 15 minutes.	Leftovers are usually reheated in a microwave oven. This process may take 1 to 3 minutes. **Note:** Some people may prefer to reheat their food on top of a stove, taking about 5 to 10 min.
drying hair	Hair was dried by vigorously rubbing a towel over the wet hair. Then the hair was left to air-dry.	Hair is often dried using an electric blow dryer (or hair dryer).

3. Check your response with your teacher or home instructor.

Section 1: Lesson 2

1. a. Statement A is qualitative (uses letters, language, and words). Statement B is quantitative (uses numbers).

b. Quantitative information is more precise and, therefore, more reliable. Qualitative data is comparative information. It relies on a reference point that must be defined. For example, what is warm? Warm depends on the situation and the person doing the interpretation. The person may say it is warm compared to the air temperature, compared to the temperature the bath water was 15 minutes ago, or compared to the temperature of the water in the sink. You may, in fact, consider the water to be warm or cool.

The quantitative measure, 25°C, is not comparative information. No matter what the situation is, who is doing the measurement, or which device it is measured with (as long as it is appropriate and properly calibrated), 25°C is 25°C.

2. You could touch something or judge by the colour of the object or material.

3. The record high was 45°C, and the record low was – 62.8°C.

4. **Textbook question 1 of "What Did You Find Out?," p. 193**

   1. The results should have been the same when the experiment was repeated after switching hands. Your interpretation of the temperature was based on the previous temperature your skin was exposed to.

5. A *thermometer* is a device used to measure temperature. This device can either be electrical or mechanical.

   Scale refers to a series of marks or points at certain intervals used to measure distances.

   The *Kelvin scale* is a temperature scale used by scientists. On this scale, water freezes at 273 K and the coldest possible temperature is 0 K (referred to as absolute zero).

6. a. The inventor chose the freezing point of pure water at sea level to represent 0°C.

   b. The inventor chose the boiling point of pure water at sea level to represent 100°C.

   c. Celsius calibrated his scale by breaking the area between his fixed points (the freezing and boiling points of water) into 100 equal parts (or degrees).

7. Impurities (dissolved substances) and pressure affect the boiling and freezing points of water. A dissolved substance makes the boiling point (which is already high) go higher and the freezing point (which is already low) go lower. The higher/lower the pressure, the higher/lower the boiling point. This is generally true for the freezing point, too. (Water, however, is a special case.)

8. Differences include the following:

   - The numbering on the scales is different. (The freezing point of pure water is 273.15 K. The boiling point of pure water is 373.15 K.)
   - There are no negative values on the Kelvin scale.
   - The values on the Kelvin scale are not measured in degrees. Each gradation is a K (short for Kelvin), not a °K.

9. and 10. Check your responses with your teacher or home instructor.

11. **Textbook question "Investigation 3-C: Boiling Hot, Freezing Cold," p. 198**

	Description	Temperature (°C)
1	temperature of lava from Hawaiian volcanoes	1150
2	temperature of ocean currents off Canada's east coast	1
3	temperature of ocean currents off Canada's west coast	4 to 10
4	world record coldest air temperature	– 87
5	comfortable room temperature	20 to 25
6	body temperature of a budgie bird	40
7	temperature where the Space Shuttle flies in orbit	–121 to –156
8	temperature of a candle flame	800
9	comfortable temperature for heat-loving bacteria	92
10	normal human body temperature	37
11	temperature of ice cream	– 5
12	oven temperature for baking bread	200
13	temperature of food in a freezer	–10 to –15
14	temperature of the interior of the Sun	15 000 000
15	temperature of hot tea or coffee	55
16	temperature of boiling water at sea level	100
17	temperature of a slush of pure water and ice	0
18	temperature of the surface of the Sun	6000

12.

Temperature Devices				
Device	**Sensor**	**Signal**	**Responder**	**Use**
thermocouple	**copper and iron wires**	**electrical current**	**switch or valve**	**measures very high temperatures**
bimetallic strip	coil of two strips of different metals, like copper and iron	• contraction completes electrical circuit • expansion breaks circuit (**Note:** The effects of contraction and expansion may be the other way around for some applications.)	switch	control furnaces, refrigerators, and air conditioners
recording thermometer	coil of two strips of different metals (bimetallic coil)	contraction and expansion of bimetallic strip	lever with pen attached moves up and down on a circulating drum	record continual temperature over a long period of time
infrared thermogram	• skin • special films • electronic sensors	skin, film, and electronic sensors detect levels of infrared radiation (IR)	• skin sends message to brain to react to IR • film turns to specific colours • electronic sensors are activated and send message to a computer	• detect areas of heat loss in buildings • find temperatures on Earth from weather and spy satellites • help car drivers at night

See "Cool Tools" on page 256 of the textbook.

13. Check your responses with your teacher or home instructor.

Section 1: Lesson 3

1. *Particle model of matter* is the scientific model of matter in which matter is depicted as consisting of tiny particles.

   Matter is anything that takes up space and has mass.

2. There are about 1 700 000 000 000 000 000 000 particles in a drop of water.

3. The particles are too small and have too little mass to be felt when they hit you.

4. **Textbook questions 1 and 2 of "Procedure," p. 202**

   1. a. solid b. liquid, gas c. gas

   2. a. gas b. liquid, solid c. liquid, gas d. solid

5. **Textbook question "What Did You Find Out?," p. 202**

   As particles gain energy, they move faster and hit each other harder. At some point, they are able to escape from the attractive forces between the particles. They change state (from solid to liquid or from liquid to gas).

   The particles of a solid are close together. They are held in place by the attractive forces between particles. Liquid and gas particles have more energy. They have enough energy to remain free and move around on their own.

   The more energy the particles have, the faster they move; the harder they hit, the more the spaces between the particles increase.

6. **Textbook questions 1, 2, and 3 of "Procedure," p. 203**

   1. a. The beating of the wings of the bee causes the air particles to increase their motion. (Also, muscles use energy to move. Heat is released into the air when the bees use the chemical energy. The air particles absorb this energy.)

      b. As the motion of the air particles increases, the temperature increases.

   2. a. The beating action causes the water particles to increase their motion.

      b. The increase in the motion of the water particles causes the temperature of the water to increase. It's just like how the beating of the wings of the bees increases air temperature.

   3. a. The temperature at the end of the drill increased as it was twirled.

      b. Friction between the two pieces of wood caused the wood particles to increase their motion. Therefore, they increased their temperature.

7. **Textbook questions 1 and 2 "What Did You Find Out?," p. 203**

    1. One item moving made another item become hotter. The first item made the particles in the second move faster. This was common to all examples.

    2. Answers will vary. Some examples are as follows:

        - rubbing one hand against another
        - fanning the air with a piece of cardboard
        - hitting a baseball

8. *Temperature* is a measure of the average thermal energy of the particles in a substance.

9. *Kinetic energy* is the energy of motion. Any moving object or particle has kinetic energy.

    Thermal (heat) energy is the total kinetic energy of all the particles in a substance.

    A *joule* (J) is the standard SI unit of energy.

10. a. Since they have the same mass, the number of particles in each cup is the same.

    b. The cup of water at 80°C has more thermal energy than the same amount of water at 20°C. While the number of particles is the same, the particles in the warmer water have an average energy (temperature) that is higher than the average energy (temperature) of the particles in the cooler water. Therefore, the total (thermal) energy of the warmer water is higher.

11. The two rules of energy transfer are as follows:

    - Changes occur when there is an energy difference.
    - Energy always moves from a higher energy source to something with lower energy.

12. a. You would need to add a very large amount of heat energy. (A huge number of particles would be absorb the heat energy.)

    b. You would need to add a relatively small amount of heat energy. (The number of particles absorbing heat energy is relatively small.)

13. Check your responses with your teacher or home instructor.

14. Check your responses with your teacher or home instructor.

15. Check your responses with your teacher or home instructor.

16. Check your responses with your teacher or home instructor.

17. Check your responses with your teacher or home instructor.

Section 1 Review

1. and 2. Check your responses with your teacher or home instructor.

Section 2: Lesson 1

1. *Expansion* is the process in which a substance increases in volume (as thermal energy is absorbed).

   Contraction is the process in which a substance decreases in volume (as thermal energy is released).

   To *compress* means to squeeze a substance so the particles of the substance are moved closer together.

   Volume is the three-dimensional size of an object or substance. It shows the amount of space an object or substance occupies.

2.

Comparing States of a Given Substance				
State of Matter	**Volume**	**Shape**	**Compressibility**	**Average Energy Level**
solid	**definite**	definite	incompressible	lowest
liquid	definite	**indefinite**—takes shape of container	incompressible	medium
gas	indefinite—fill the container	indefinite—takes shape of container	**compressible**	highest

3. The phase change from solid to liquid requires thermal energy. The same is true for the liquid-to-gas and the solid-to-gas phase changes. The state of a single substance is related to its temperature. It will generally be a solid below a certain temperature. It will become a liquid at that temperature. It will remain liquid as its temperature is raised. At another higher temperature, it will become a gas. These temperatures are different for different substances. For example, iron will be a solid at 150°C; water will be a gas at 150°C. This is why the chart refers to a given substance.

4. **Textbook questions a. and b. of "Pause and Reflect," p. 210**

   a. They are all made of the same type of particle.

   b. When water is heated, its particles become more active. (Its temperature rises.) The motion in ice is much less than that in liquid water. The liquid water particles are much more active. The motion in water vapour is even greater.

5. **Textbook question 1 of "Procedure," p. 211**

    1. a. All the materials increase in length when they are heated.

        b. Although they all increase in length, they do not all increase the same amount.

        c. Lead expands the most as it warms.

        d. Pyrex® expands the least as it warms.

6. **Textbook question 1 of "What Did You Find Out?," p. 211**

    1. Things that expand a lot when heated also contract a lot when cooled. Yes, the material that expanded the most contracted the most.

7. Check your responses with your teacher or home instructor.

8. Check your responses with your teacher or home instructor.

9. **Textbook questions a. and b. of "Pause and Reflect," p. 214**

    a. The gases in the can would absorb thermal energy. This causes the volume of the gas to increase (expand). The can may explode due to the increased volume.

    b. The gas in the tires contracts (decreases in volume) as the air particles lose thermal energy.

10. Plasma is the fourth state of matter. Under extremely high temperatures, the particles break into a soup of tinier particles.

11. a. The circumference of the balloon decreased. The gases contracted (volume decreased) when its particles were cooled (lost energy).

    b. The circumference of the balloon increased. The gases expanded (volume increased) when its particles were heated (gained energy).

    c. When the air particles inside the balloon are heated, they gain kinetic energy. They move faster, hit each other harder, and move farther apart. This forces the walls of the balloon out. The volume of the balloon increases. This means the circumference will also increase. The opposite happens when energy is removed. (The gas is cooled.)

12. The thin tube is called a bore.

13. **Textbook questions 1, 3, and 4 of "What Did You Find Out?," p. 216**

    1. The liquids expanded different amounts.

        a. Oil expanded the most; alcohol was next; and water expanded the least.

        b. Yes, oil contracted the most.

3. Answers will vary depending your hypothesis.

4. a. Oil would be best. To see small changes in temperature easily, a large change in volume is best.

   b. Alcohol or water would be suitable. They don't expand too much, so a large tube would not be needed.

14. Check your responses with your teacher or home instructor.

Section 2: Lesson 2

1. *Heat capacity* is the amount of thermal energy that must be absorbed or lost to change the temperature of a substance or object 1°C.

   Specific heat capacity is the amount of thermal energy that must be absorbed or lost to change the temperature of a unit amount (1 g or 1 kg) of a substance 1°C.

2. Water has a higher specific heat capacity. Energy is being added to both the sand and the water at an equal rate. The sand heats up faster. This indicates that its particles "hold" less heat energy per degree of temperature change. The sand particles heat ("fill up") faster than water particles.

3. Check your response with your teacher or home instructor.

4.

Relating Heat to State Changes

Change of State	Thermal Energy Change Required (added or removed)	Initial State (solid, liquid, or gas)	Final State (solid, liquid, or gas)
melting	added	solid	liquid
freezing	removed	liquid	solid
condensation	removed	gas	liquid
evaporation	added	liquid	gas
sublimation (solid to gas)	added	solid	gas
sublimation (gas to solid)	removed	gas	solid

5. a. condensing b. sublimation c. melting

6. Melting and freezing points are the same for any one substance. For example, the melting and freezing point of water is 0°C. They are different in that energy is being absorbed when the substance melts and released when the substance freezes.

7. a. Tin, lead, aluminum, table salt, silver, gold, and iron are frozen at 21°C.

   b. Water and mercury are liquid at 21°C.

   c. Oxygen is a gas at 21°C.

8. a. Paraffin wax melts at about 150°C.

   b. There was a flat part (plateau) on the graph. The temperature remained the same even though energy was still being added. When thermal energy is added or removed, one of two things will happen. The temperature will change or the state will change.

9. When you exercise, your body temperature increases as your muscles burn energy. Your body is adapted to regulate your body temperature. It releases sweat through pores onto the surface of your skin. The sweat absorbs heat from your skin and evaporates. This lowers your body temperature.

10. a. Answers will vary. A sample answer is given.

    While solid ice changes to liquid water, the temperature will **stay the same** because **the energy being absorbed during a phase change is used to help the particles overcome the attractive forces between them, thus escaping from the solid to become liquid.**

    b. Answers will vary. A sample answer is given.

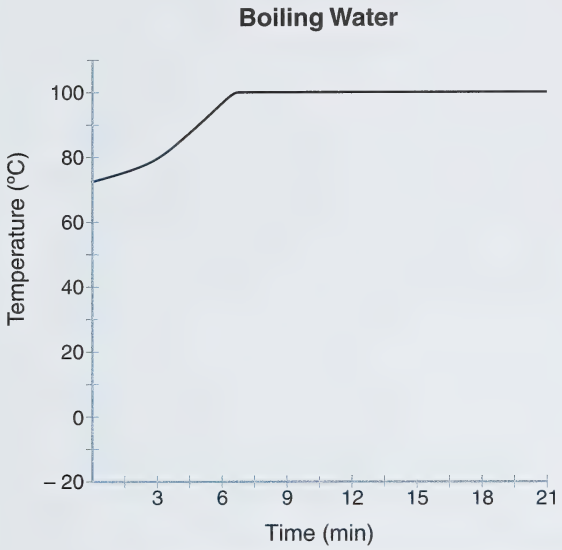
    While liquid water boils into gas, the temperature will **stay the same** because **the energy being absorbed during a phase change is used to help the particles overcome the attractive forces between them, thus escaping from the liquid to become gas.**

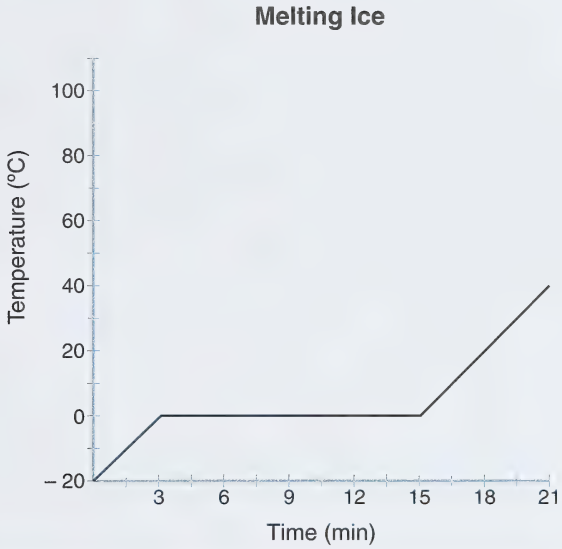
11. a. **Textbook questions 1, 2, 3, 4, and 6 of "Analyze," p. 223**

    1. a. RV: temperature of the sample

       b. MV: the amount of time the sample is heated

2. The line graph would vary in accordance with each student's results.

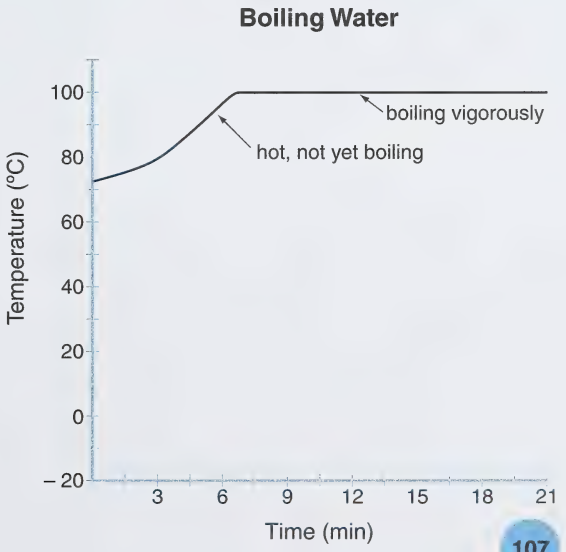




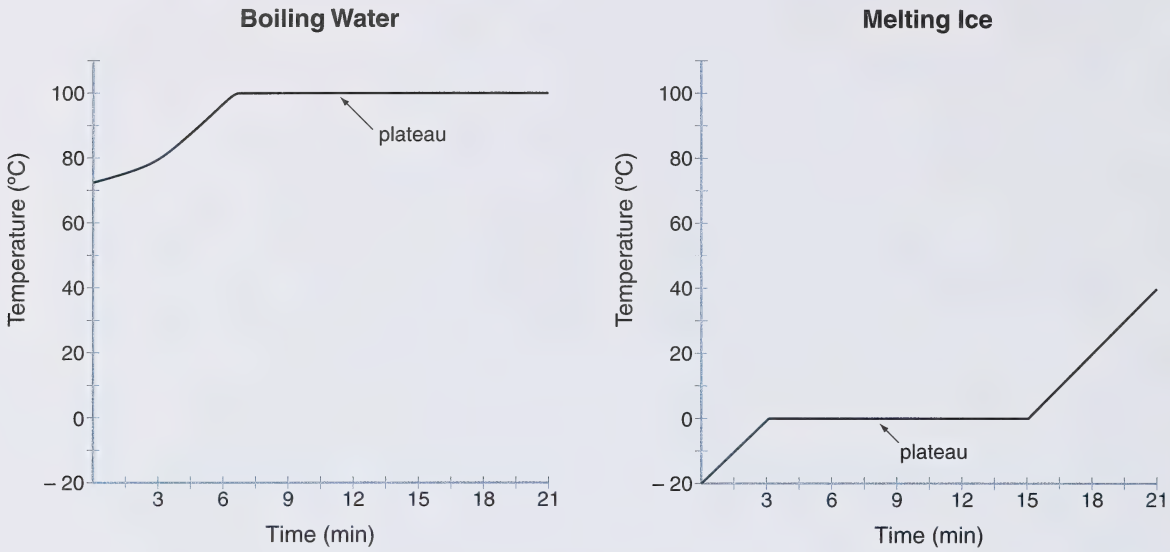
Note: The more finely crushed the ice is, the closer the line will be to 0°C. The temperature will remain at this plateau longer as well. Remember that the thermometer measures average energy level. The temperature of solid water cannot be higher than 0°C. (All absorbed energy is used for the phase change.) Once it has changed to a liquid, however, the temperature will increase as energy is absorbed. It is likely that you measured a temperature somewhat higher than 0°C during most of the melting phase because the thermometer indicated the combined average energy level of both the solid and liquid water.

The horizontal line represents the melting point of water. The temperature will rise (line will slant upward) before and after this plateau as the temperature of the solid and later the liquid increases.

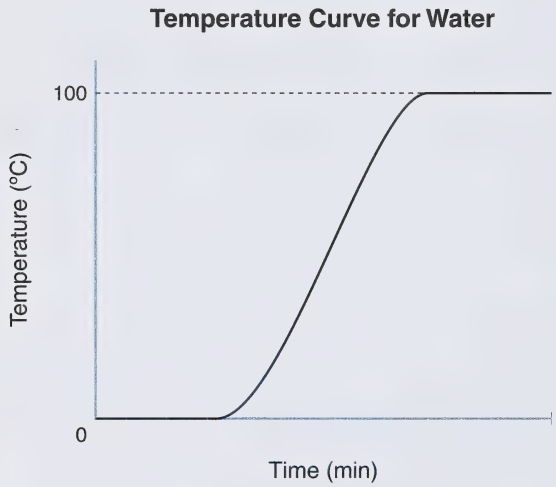
3. The upward slanting part of the line shows where the water was hot but not yet boiling. The horizontal part of the line shows where the water is boiling vigorously.



4. You should have a plateau while the water is boiling vigorously and while the ice is melting.



6. At the points where the water was melting or boiling, the line should be horizontal. The line should slant upward above and below the plateaus (flat sections). A sample graph follows:



b. **Textbook questions 9 and 10 of "Conclude and Apply," p. 223**

9. The temperature of a substance does not change during a change of state. All the energy being absorbed during a phase change (melting or boiling) is used to free the particles. The energy removed during a phase change (condensation or freezing) allows attractive forces to reposition the particles into the new state. The average energy of the particles (temperature) remains the same in both cases. However, the total energy of the particles does change. Your thermometer cannot detect this change. This "hidden heat energy change" must be detected in other ways.

10. Answers will vary depending on your observations and hypothesis.

12. You can tell when a substance is changing state because the heating curve **plateaus (or goes straight or stays at the same temperature or is horizontal until the change of state is finished)**.

13. a. As temperature increases the particles become **less** organized.

    b. As temperature decreases, the particles become **more** organized.

    c. During a change of state, the total energy of all the particles in the substance **increases or decreases** and the average energy of the particles (temperature) **remains constant**. The energy that is absorbed or lost changes the **arrangement** of the particles rather than their temperature.

14. Check your responses with your teacher or home instructor.

Section 2: Lesson 3

1. *Heat* is thermal energy transferred from a warmer substance to a cooler substance.

   Conduction is a method of heat transfer from particle to particle by touch.

   Convection is a method of heat transfer in which lighter, warmer, less-dense fluids (gas, liquid) are pushed upward by heavier, colder, denser fluids.

   Radiation is a method of heat transfer from particle to particle using electromagnetic waves.

2. a. convection

   b. radiation

   c. conduction

3. *Radiant energy* (electromagnetic radiation) is energy that transfers in the form of a wave.

4. All radiant energy behaves like waves, can be absorbed or reflected, and travels at very high speeds through space (a vacuum or the spaces between particles). It is interesting to note that radiant light energy from the Sun takes about eight minutes to reach Earth! A fourth characteristic—radiant energy travels in straight lines—explains why your back is cold when you sit facing a raging fire. The infrared radiation cannot curve around to warm your back.

5. Radiation is the only method of energy transfer that does not require the assistance of particles.

6. and 7. Check your responses with your teacher or home instructor.

8. a. **Textbook questions 1 and 2 of "Procedure," p. 228**

1.

Surface Characteristics and Radiant Energy Transfer			
Surface	**Ability to Absorb**	**Ability to Radiate**	**Ability to Reflect**
light-coloured	worse	worse	better
dark-coloured	better	better	worse
shiny texture	worse	worse	better
dull texture	better	better	worse

2. a. The best reflector is one that is light-coloured with a shiny reflector.

   b. The worst reflector is one that is dark-coloured with a dull surface.

   c. The best absorber is one that is dark-coloured with a dull surface.

   d. The worst radiator is one that is light-coloured with a shiny surface.

b. **Textbook question 3 of "Analyze," p. 228**

3. You could choose surfaces to absorb or reflect radiant energy to modify the temperature of your house or heat water.

9. A *heat insulator* is a material that conducts heat poorly.

10. Thermal conduction is like a chain reaction in that one particle touches and passes energy to another particle, which touches and passes energy to another particle, and so on.

11. **Textbook questions 1 and 2 of "What Did You Find Out?," p. 229**

1. a. wood or plastic

   These substances are poor conductors. Heat will not be transferred to your fingers.

   b. copper or other metal

   The bottom should be a good conductor. This way the heat of the stove is transferred to the food in the can.

c. wood or plastic

These are poor conductors. Heat will not be transferred to your hands.

d. wood (In real life, cardboard is used because it is lighter, cheaper, and still insulates pizza.)

The insulating qualities of a container help keep the pizza hot.

2. The particles in an insulator could be spaced further apart than the particles in a conductor. They have higher specific heat capacities (must absorb more heat to increase 1°C in temperature). So, they take longer to warm up and then transfer energy. The greater the difference in temperature, the faster heat energy transfers.

12. A *convection current* is a roughly circular pattern that results from the uneven heating or cooling of a fluid.

Density refers to how closely packed or thick a substance is. It is a measure of the amount of matter (number of particles) packed into a particular volume.

A *fluid* is a liquid or a gas.

13. Solids cannot transfer heat by convection. The particles are not free to move individually. They are fixed in place.

14. In Situation 1, conduction was the primary method of heat transfer. In Situation 2, the primary method was convection. In Situation 3, it was radiation.

15. Particles in the metal absorbed energy from the flame. They moved faster, and in the tightly packed solid, they collided with the next particle(s). During collisions, the faster moving particles transferred energy to the cooler (lower kinetic energy) particle(s). The newly energized particles then collided with their neighbouring particles and transferred energy to them. This continued in a series of chain reactions until it spread throughout the metal from the heat source to your hand.

16. Actually, you experienced all three. Radiant energy transfers equally in all directions, so some of the heat energy moved directly from the flame to your hand as radiation. Most of the heat from the flame is carried upward from the flame by particles (convective heat transfer). Your skin absorbs the thermal energy from these particles by conduction when the hot particles touch your skin.

17. Convection is the primary method of heat transfer in a fluid. You quickly notice the heat above the flame. Heat is reaching your hand by both convection and radiation. Radiant heat transfer is equal in all directions. Convective heat transfer is only upward. At the side of the candle, you only experience radiation. Did you notice how much closer you can get to the side of the flame and how much longer you can hold your hands there? Much more heat is transferred by convection than by radiation.

18. Heat is not a substance. It is a form of energy.

19. The energy source is the fire.

    The direction of energy transfer is from the fire to the surroundings.

    Energy transformations include the following:

    - chemical energy of the burning wood to heat and light energy
    - heat and light energy to kinetic energy of air particles, the particles on the surface of the boy's skin, and the food

    Heat is wasted to the surrounding air particles if you and your food are the target.

    The control system is as follows:

    - amount of wood on the fire
    - water to lower the flame or douse the fire
    - amount of oxygen the fire receives (Have you ever lifted a log in the fire to allow more oxygen at the coals?)
    - how close you and your food get to the fire

20. Heat is lost through the chimney, walls, around doors and windows, as well as through the window glass.

21. RSI is an indicator of a material's resistance to heat conduction. It is based on using a 1-cm thick piece.

22. Blue plastic foam panels are the best insulators (highest RSI/resistance). Glass is the best conductor (lowest RSI/resistance).

23. $10 \text{ cm} \times 0.24 \text{ RSI/cm} = 2.4$

    The RSI is 2.4.

24. Answers will vary. The following ideas may be included:

    - Use materials that are better insulators. For example, use a down-filled comforter as an additional layer of insulation.
    - Design a structure to provide for less heat transfer by radiation. For example, place aluminum foil just under the final layer of insulation. The foil should prevent radiant heat from reaching the ice cube.

25. Check your responses with your teacher or home instructor.

Section 2 Review

1. and 2. Check your responses with your teacher or home instructor.

Section 3: Lesson 1

1. Fractional distillation (vapourizing and condensing the different fractions/parts of the oil) is used to break crude oil into usable parts.

2. **Textbook questions 2 and 3 of "What Did You Find Out?," p. 238**

   2. Answers will vary. They should include some of the following points:

      - Wood needs to be located.
      - Wood needs to be purchased.
      - Wood needs to be cut and stacked.
      - Wood needs to be transported.

      If it were a large operation, machinery would be needed to load and unload wood. A smaller operation might require human energy to be expended.

   3. The energy inputs include the following:

      - seismic equipment to locate gas
      - drilling machinery to reach gas
      - human labour involved in transporting and running machinery
      - technology, equipment, and human labour needed to install pipeline
      - materials and human labour involved in building, transporting, and installing the appliance

3. *Energy* is the ability to do work, move, or cause a chemical or physical change.

   Electrical energy is energy due to the flow of electricity.

   Mechanical energy is energy in a moving object or in moving parts of an object.

4. The temperature must be fairly high because the lines are sagging. It is likely that they have expanded. If it was cold, they would likely be taut (tight).

5. The kinetic energy of the moving hammer is transferred to the particles in the nail. The particles rub vigourously against each other. Friction converts their kinetic energy into thermal energy. Also, if the nail is being driven into a piece of wood, the nail particles come in close contact with the wood particles. There is friction. This gives a further increase in temperature.

6. Harnessing geothermal energy requires a variety of structures to direct, control, transfer, and convert the energy. Geothermal energy is not considered a primary energy source in Alberta because there are limited sites where geothermal energy is generated. In addition, most of these sites are located in very sensitive regions, like Banff National Park.

7. The southern portion of Alberta has very strong, reliable winds that can generate electricity. Generating power from the kinetic energy of the wind is still more costly than more traditional methods.

8. *Geothermal energy* is thermal energy obtained from the Earth's hot interior.

   Solar energy is energy obtained from sunlight.

   Wind energy is energy obtained from wind.

   Passive solar heating is a type of solar heating that relies on architectural design rather than mechanical means to collect solar energy.

   Active solar heating is a type of solar heating in which mechanical means are used to store, collect, and distribute solar energy in buildings.

   Solar collectors are parts of an active solar heating system that absorb the solar radiation shining on their surface.

9. Radiant light energy from the Sun (solar energy) can pass through window glass. Heat energy can only pass through glass by conduction. Passive solar heating takes advantage of this. Light energy is allowed to enter a room, it is absorbed by the materials in the room, and is then converted into heat energy. The heat energy is transferred to the air particles in the room. Passive solar heating takes place only when the Sun is shining. Active solar heating involves the use of mechanical devices, solar collectors, pumps, and valves to absorb, convert, store, and distribute the energy. Rooms without direct sunlight can be heated and the stored energy can be released after the Sun goes down.

10. Most Albertans take advantage of passive solar heating to some degree. All you need is a window and some sunshine. Active solar heating is not used widely in Alberta because the days are short in the winter when heat is really needed. It would be necessary to supplement solar heating with other heating methods, increasing costs substantially. To install the mechanical devices to actively store and distribute solar energy in older homes would require large sums of money for renovations.

11. A *non-renewable resource* is an energy resource that takes over millions of years to naturally replace itself.

    A *renewable resource* is an energy resource that can be recycled or replaced by natural processes in less than a hundred years.

    A *greenhouse gas* is a gas resulting from the burning of fuels that traps thermal energy within the atmosphere.

    An *energy resource* is an object or material from which energy is transferred or, simply, a source of energy.

    A *fossil fuel* is any fuel made up of the remains of organisms that died millions of years ago and were buried deep underground.

12. Natural gas and petroleum is expected to last for only about 50 years. Coal is expected to last about 1000 years.

13. Less heat is able to escape Earth's atmosphere when greenhouse gases, such as carbon dioxide, absorb it. Many scientists believe that the use of fossil fuels by humans is at least partially responsible. There has been a gradual increase in the overall temperature of the Earth's atmosphere (the greenhouse effect).

14. Average global temperatures have risen 2.5°C in the last few decades. This does not seem like a lot, but it has already affected weather and precipitation patterns. The melting rate of glaciers and icecaps have increased as well.

15. ___D___ chemical (Rockets are propelled by fuels high in chemical energy.)

    ___B___ fossil fuel (Petroleum is a fossil fuel.)

    ___A___ solar (The solar panels collect solar energy.)

    ___C___ wind (The windmills convert wind energy to electrical energy.)

16. Check your responses with your teacher or home instructor.

17. *Thermal pollution* is the release of waste thermal energy that causes unintended heating of the environment.

18. Check your responses with your teacher or home instructor.

Section 3: Lesson 2

1. Instead of brushing off and breathing in fine particles of horse manure, people are brushing off and breathing in fine particles of rubber, as well as particles released from vehicle exhaust. To this, numerous other pollutants have been added—by-products of burning fossil fuels in our vehicles. The automobile is not the wonderful, pollution-free device it was originally envisioned to be.

2. Check your responses with your teacher or home instructor.

3. a. **Textbook questions 3 and 4 of "Analyze," p. 251**

   3. The results would likely vary somewhat. Things that would affect the results are as follows:

      - the speed with which the tin was wrapped in paper
      - the exact starting temperature
      - the precision of the time and temperature readings
      - the way the tin is wrapped

   4. Heat lost through conduction occurred when the hot water particles touched the sides of the tin, which in turn touched the paper, which in turn was in contact with the air particles.

      Heat lost through convection occurred when the warm air escaped from the top of the can.

      Heat was slightly lost through radiation from the outer surface of the can to the air around it.

   b. **Textbook questions 5 and 6 of "Conclude and Apply," p. 251**

   5. The greater the thickness of the insulating material, the greater the resistance to heat transfer by conduction. This results in a higher RSI.

6. It is not a great insulator in flat, closely packed sheets. It is, however, used as attic insulation after it has been roughly ground and treated with a fire-retardant chemical. Grinding and fluffing creates many tiny dead-air spaces that prevent the conduction of heat energy.

4. Evaporation occurs indoors, removing heat from the household air.

5. The EnerGuide label tells you how much electricity the appliance would use in one year.

6. **Textbook questions 1, 2, and 3 of "Analyze," p. 253**

    1. Some heating methods are more energy-efficient than others because they need less energy to produce the same amount of heat.

    2. Gas stoves require the smallest energy input.

    3. The gas stove seems to be a strong candidate. However, you would want to know the cost to the environment to produce this gas. You must assume that the cost of the energy production covers the cost of all the inputs. Electricity takes less time, but costs more than gas. Therefore, you must wonder what additional inputs are needed to bring the electricity to the house.

7. The furnace or hot-water heater can ignite the fumes of fuels and some solvents and paints.

8. If the oven mitt is a poor conductor, then it is also a good **insulator**.

9. Sulfur dioxide combines with water in the linings of the eyes, nose, and throat to form sulfuric acid. Sulfuric acid is very corrosive; it breaks materials down.

10. Two symptoms of carbon monoxide poisoning are dizziness and confusion.

11. Check your responses with your teacher or home instructor.

12. to 15. Check your responses with your teacher or home instructor.

16. to 20. Check your responses with your teacher or home instructor.

21. and 22. Check your responses with your teacher or home instructor.

Section 3 Review

1. and 2. Check your responses with your teacher or home instructor.

Module Summary

1. to 4. Check your responses with your teacher or home instructor.

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